THE AËRONAUTICAL JOURNAL

APRIL, 1909

The Aëronautical Journal

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NOTICE.—Owing to the increasing cost of the *Aeronautical Journal*, the Annual Subscription will be raised to Six Shillings from this date.

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NOTICES
OF
The Aëronautical Society of Great Britain

At a Council Meeting of the Aëronautical Society of Great Britain, held at 53, Victoria Street on Thursday, January 28, 1909.

1. The under-mentioned gentlemen were elected members of the Society:

GENERAL SIR R. HARRISON, G.C.B. R.E.
MR. W. H. BERESFORD
MR. J. KITCHING, F.R.G.S.

To date December 31, 1908.

CAPT. W. G. DE CARTERET
LIEUT. A. D. DE R. MARTIN, R.E.
COL. J. H. COWAN, R.E.
MR. J. T. DUNCANSON, M.A.
MR. F. TOLLEY
MR. C. URBAN
CAPT. J. CLEMINSON, 5TH ROY. IRISH FUSILIERS
MR. EDWARD REYNOLDS
MR. CHARLES HOARE
MR. H. C. LACELL
MR. A. W. ISENTHAL
MR. L. G. DAVIES
MR. F. H. BUTLER
CAPT. BATES VAN DE WEYER, SCOTS GUARDS
MR. F. J. HEALEY
CAPT. C. E. SCHLESINGER, R.F.A.

To date January 28, 1909.

2. The Bronze Medal of the Society for the best paper published in the Journal of the Aëronautical Society of Great Britain during the year 1908 was awarded to:

MR. W. R. TURNBULL, M.E.,

for his paper on "The Efficiency of Aëroplanes, Propellers, and Motors."

3. In recognition of his long and distinguished services to Aëronautical

Science, the under-mentioned gentleman was appointed an Honorary Member of the Society:

Lt.-Col. J. L. Templer, late Superintendent of the Government Balloon Factory.

At a Council Meeting of the Aëronautical Society of Great Britain, held at the Meteorological Office, 70, Victoria Street, Westminster, on Thursday, March 4, 1909.

1. The undermentioned gentlemen were elected Members of the Society:

Capt. W. J. Rodd, A.O.D.
Hon. Alan R. Boyle
Mr. A. G. New
Col. F. G. Stone, R.A.
Mr. S. N. Neild
Sir J. Carden, Bart.
Mr. W. W. Buckton
Lt. T. F. Besant, R.N.
Mr. E. S. Mackenzie-Hughes
Mr. R. Lionel Foster
Mr. Stanley Spooner
Mr. F. Fitzgerald O'Hagan
Mr. C. H. Gadsby
Mr. H. E. Goody
Mr. A. J. Aitken
Mr. C. E. Wright
Mr. Siegfried Landsberger
Mr. H. L. Groom
Mr. J. Donovan
Mr. B. J. P. Roberts
Mr. H. Norrie
Major H. A. Sullivan, A.V.C.

To date March 4, 1909.

At a Council Meeting of the Aëronautical Society of Great Britain, held at 53, Victoria Street, Westminster, on Tuesday, April 6, 1909.

1. The undermentioned ladies and gentlemen were elected Members of the Society:

Capt. E. Maitland Maitland
Mr. H. M. Lyons
Lieut. C. S. Head, R.N.
Miss Amy Gretton
Mr. F. K. McClean
Mr. Leslie A. Young
Mr. W. T. Douglass
Mr. B. Clutterbuck
Mr. E. Newbold
Mr. G. T. Moore-Brabazon
Mr. F. P. Walsh
Miss Fullerton
Mr. J. Dick
Mr. C. Hearson
Mr. H. Donnithorne
Lieut. W. de M. Egerton, R.N.
Mr. F. R. Gascoigne, J.P.
Mr. W. Pitt
Mr. H. Massac Buist
Mr. C. Bright
Mr. G. L. O. Davidson

To date April 6, 1909.

MISCELLANEOUS NOTICES

1. The Council desires to thank the donors for the following books, pictures, etc., presented by them:

By Colonel Trollope (late Grenadier Guards)
La Conquête de l'Air (current numbers).

By Major Baden-Powell (late Scots Guards)
"The Science Year Book."
"The Reign of Law" (Duke of Argyll).
A Collection of Prints and Photographs.
A Collection of Magazines and Newspapers.

By Mr. C. Bright,
"The Life of Sir Charles Bright, M.P." (an original Member of Council of the Aëronautical Society of Great Britain).

By Mr. P. Y. Alexander
A Demonstrating Apparatus for Propellers, complete.
"The Internal Combustion Engine" (Wimperis).
"The Screw Propeller" (Barnaby).
A Large Collection of Pamphlets, Papers, etc.

By the Aero Club of America
"Navigating the Air."

By the Society of Engineers
"Report of a Lecture given by H. Chatley, Esq., B.Sc. (Member of the Aëronautical Society of Great Britain)."

By Sir E. Barry, Bart.
A Collection of Pamphlets, Papers, etc.

By Mr. W. Bennett
A Collection of Lantern Slides.

By Major Moore (late R.E.)
Some Pictures.

By Mr. T. O'B. Hubbard
Some Prints.

By Mr. E. S. Bruce, M.A.
"Some Forms of Scientific Kites."

By Mr. F. H. Butler
"5,000 Miles in a Balloon" (6 copies).

By M. Estournelles de Constant
"Pour l'Aviation."

2. Members and others contributing to the Journal are requested to kindly observe the following rules when drawing up their MSS.:

(*a*) Write on one side of the paper only.

(*b*) Leave a margin one inch wide on the left-hand side.

(*c*) Draw diagrams, etc., on very white paper with very black ink, as this greatly simplifies reproduction.

(*d*) Forward their communications to the Hon. Secretary at least 14 days previous to the date of the meeting at which the paper is to be read. Papers containing diagrams, sketches, etc., which it is required to show on lantern slides, should be sent in as early as possible.

3.—The attention of Members is drawn to the Circular inserted in this Number of the Journal, respecting the Society's exhibit at the forthcoming International Travel Exhibition.

4. It is proposed to devote a part of the Journal to short accounts of the progress made by Members in the aëronautical work undertaken by them. Members who are willing to contribute information of this kind are requested to forward their reports (which should not exceed 300 words in length) to the Hon. Secretary not later than June 20, 1909, for insertion in the July number of the Journal.

5. In order to complete the Society's sets of Reports, etc., two copies of each of the undermentioned are required:

Annual Reports—

1866	1st Annual Report.
1867	2nd Annual Report.
1874	9th Annual Report.
1877	12th Annual Report.
1883	18th Annual Report.
1884	19th Annual Report.

The *Aëronautical Journal*, Nos. 2 and 9.

The Council hopes that Members who can spare any of the above will present them to the Society so as to complete its Library Records.

6. The following letters are published for general information:

51, Castletown Road, W.,
Feb. 3rd, 1909.

Dear Colonel Fullerton,—I wish to ask you to express my great appreciation for the honour that the Aëronautical Society of Great Britain has conferred on me in making me an Hon. Member. That I accept with pleasure.

Yours very sincerely,
(Signed) JAMES TEMPLER.

Rothesay,
New Brunswick,
Feb. 8th, 1909.

Col. J. D. Fullerton, R.E.,
Hon. Sec. Aëronautical Society
of Great Britain.

Dear Sir,—In acknowledging your letter of January 29th, 1909, I wish to thank the Council of the Aëronautical Society most heartily for their generous award. The paper was not written under very favourable circumstances, and I have been taken by surprise by such kindly recognition.

The award is most encouraging to me, and I shall put forth the effort to do something, in the experimental line, very much better, I hope, during the present year.

I am, Sir,
Sincerely yours,
(Signed) W. R. TURNBULL.

GENERAL MEETING

The opening meeting of the Forty-fourth Session of the Aëronautical Society of Great Britain was held at the Royal Society of Arts, John Street, Adelphi, on Friday, March 26th, 1909, the chair being occupied by Major B. Baden-Powell (Vice-President), who, on opening the meeting, said:—

"Ladies and Gentlemen,—First of all I must state with much regret that Mr. Frost, who was to have taken the chair to-night, is unfortunately taken ill and will be unable to attend, having caught a chill. I think that before we get on to the meeting I might make some refer-

ence to recent developments that have occurred in the subject which we all have so much at heart. Great progress has been made, not so much with the improvement of apparatus for navigating the air as in the interest which the public, especially the British public, have been taking in the subject. The Press have taken the matter up a great deal more of late than they have done formerly, and that has created a public interest in the subject. The Exhibition which is now going on at Olympia has added very much to this interest. There is one thing that occurs to me that I think we ought to take note of, and that is that there is almost too much of a rush at present to develop this matter. We find here somebody who wants to start a new Society, and there somebody who wants to start a new trial ground, and there is somebody else who wants to start a new paper, and others are going in for a new aëroplane factory. Now, it seems to me that all this rush, like a sort of panic, is rather overdone, and that by introducing too many of these new institutions they are only doing harm to the older ones, and are not likely to bring success to the new ones. The Exhibition at Olympia, as you all know, has proved a very great success, and it is specially noteworthy that it has been a means of showing that the British makers of these instruments are not to be behind hand, because I think it is very generally agreed that some of the British-made machines compare very favourably with those of foreign make—at all events as far as appearance goes. Unfortunately very few of these have been tried, and we must not, therefore, be too cock-a-hoop that our British machines are better than foreign ones. And it is not only in the machines for flight, but amongst the motors and engines that we see some very neat-looking English-made machines. All this makes us rather hope that the Exhibition which is to take place in July at Olympia, with which this Society is more directly concerned, will also prove a great success, because the public, who are now only beginning to take an interest in the matter, will have by this Exhibition seen something of machines, and are likely to take a still further interest in them, and after four months of thinking the matter over I hope that we shall have many who are really keen to go into the subject, and who, therefore, will render the July Exhibition a success. We hear that there are a number of visitors to this Exhibition who have actually bought machines. It seems to me as if that were rather a pity, although it seems odd for me to say so, but I am inclined to think that there are several people who have rushed into the matter without due consideration, and may find themselves very much disappointed. They spend hundreds of pounds over getting a machine which has never flown and is not likely to fly without a great deal of experiment and trouble. I am afraid some of those people will be very much disappointed if they expect to fly straight off. That brings one to another question, which is that of trial grounds. There have been started quite a number of different grounds, very often more or less of a commercial speculation, for the trial of these machines, and, of course, you all know about our ground at Dagenham, and I think I may say that that ground ought, as far as we can see, to be quite superior to any of those I have heard of. We are very anxious to improve it. It is capable of very great improvement, but we—I am speaking now in the name of the Committee of Management of the ground—are very anxious to hear the opinions of members, especially those who are wishing to try their machines there, to know in what way they would like the improvements carried out. Some say they want a flat piece of ground to run their machine along on for fifty yards, others say they want a large open area, and they don't mind whether the surface is rough or smooth; others say they only want a lake to try their machine over. If we get the opinions of the different members and exactly what they want we shall know very much better how to use the funds. I am thankful to say that, owing to the generosity of some of our members, we have got a good fund in hand for the purpose of improving the grounds, and we are only anxious to know exactly the best way of investing this money, and, therefore, we shall be very glad to hear the opinions of any members. With those few remarks I will call upon Mr. McKinney to read his paper on 'Aërial Motors.'" (Applause.)

Some Points in Aëronautical Engines

By A. J. McKINNEY, M.A., A.I.A.E.

Aërial navigation has developed at such an extraordinary rate during the last year or so that, in some senses, it has shown the same tendencies innate in all kinds of speedy evolution. That is, the science has had, in its upward progress, to make use of materials just because they were to hand, rather than for any special value or property fitting them peculiarly for aviation. But lest I should seem to cast an unjust reflection upon the new science, let me hasten to add that, first of all, we cannot very well conceive of progress along other lines, and secondly, that in doing this it merely follows a universal law. Man, in his empiric moments, follows first of all what he has had experience of, the objects around him, the forces that come under his ken, and then, finding them, perhaps, unsuitable, launches boldly out, once the foundation has, so to speak, been laid, into fresh and unknown paths. Hence it is that we find early attempts at flight to be confined to a close imitation of birds; wings naturally appearing the one and only solution of the problem. Thus we have the ancient myths of Icarus, the historical experiment of Archytas of Tarentum, and quite recently, comparatively, the bat-like Avion, constructed a dozen years or so ago by the ingenious M. Ader.

In regard to the second point I mentioned, that aërial navigation follows at first the lines taken by every new development of human genius, I need only mention the automobile, understanding by this term the petrol car, which in its early forms, say ten or twelve years ago, was an absurd compromise between an old-fashioned brake, minus the horse, and a somewhat ungainly tricycle. Inventors of the period were only too delighted to get a small internal combustion engine that would run at all, to care about the chassis, the transmission, or the coachwork. All these came later, in due course, which is obviously just what we would expect. In the same way aërial navigation has not developed *de novo*, neither is any type of flying machine "built in a day," any more than Rome was. In other words, we may take it that, in spite of progress which is really astounding, we are really only at the *fons et origo* of the science. This being so, we have first of all to find out what is required to improve flying machines, and then, having done this, to set about evolving types essential to rapid progress.

You will observe that I have opened up a tremendous vista, one whose magnitude frightens me so that I must, like the shell fish of renown, retire precipitately into my shell. In doing this I will disappoint, no doubt, many enthusiasts present to-night, who are longing to get a chance to discuss the size and form of planes, the shape and nature of dirigible envelopes, and the properties of various types of propellers.

My particular purpose to-night, however, is to discuss engines especially designed for aëronautical service, and particularly to treat of difficulties in using them under such novel conditions.

At the outset I may as well remark that the engines used to-day in all types of flying machines are little more than motor-car engines, considerably improved in some respects certainly, yet not so efficient in others. Whether aëronauts should demand a motor of entirely different design for flying machines, and, moreover, expect to get it at once, is another point. At the rate things are going at the moment, it is quite on the cards that something will appear soon which will give the necessary power, while having the two virtues of lightness and automaticity. In the meantime, however, we have a very useful *pis aller* in the modified car engine as used in modern flying machines, and by paying attention to certain points, we will be enabled to obtain very fair satisfaction from them.

But, after all, it is no reflection upon aëronautical engines to say they are similar to car types, for anyone who is acquainted with the latter in its best forms cannot but wonder at the *multum in parvo* they represent. For power, lightness, compactness, durability, and ease of control they are unequalled as artificial sources of energy, and, under ordinary road conditions, give excellent results. When, however, we transplant them to another field, we naturally handicap them somewhat, and, there-

fore, are not justified in blaming them if they are inefficient. For example, amongst the drawbacks from which aëroplane engines suffer is the lack of attention or "nursing" during actual flight, a point which needs special attention from designers in view of these unusual conditions.

There are four essentials for motors used in aëroplanes, and, indeed, all are really just as necessary in engines used for dirigibles. They are (1) Lightness; (2) Efficiency; (3) Reliability; (4) Automaticity. The first three qualities are obviously required in engines installed in any type of flying machines, although, of course, there is not the same need for the first in the case of a dirigible balloon as in that of an aëroplane. Automaticity, too, is clearly more desirable in the last-mentioned machine, since the motor has to be left largely to its own devices, while another on board the larger craft can receive the necessary attention.

Yet even the buoyancy of the dirigible balloon is not great enough to support an unnecessary load, and everything must be done that is possible to cut down unnecessary weight. In certain directions only is this possible, the chief of which are the engines themselves. Moreover, the carburation and cooling systems call for expert treatment in this respect too, while a good deal can be done with ignition and other accessories. As regards the engines a great deal of improvement has recently been made, suitable alloys making it possible to cast cylinders with very thin walls and pistons of fragile character, in each case with a fair certainty of success. Cast steel is as good as anything for the cylinders, but care must be taken to see that there are no blow-holes or flaws. The construction is much simplified by using copper or aluminium water jackets, as the engine is easier to cast and to machine, while defects can hardly escape notice. Though a good deal has recently been heard in France of the good results given by steel pistons, it is better to use cast-iron when the cylinders are of steel, as the chance of a "seize" is then greatly minimised. Lightness of the reciprocating parts, the comparatively small size of the crank case, and in some instances the absence of a fly wheel, also help to reduce weight materially. Another important fact is the increase in the number of cylinders for any given output, *i.e.*, the recent practice of using eight or sixteen where formerly two or four would have been found. Then, again, weight can be saved in the cradle or supporting arms, the transmission gearing, and control arrangements, points which, however, hardly require treating here. In addition, the aëronautical designer has this advantage over his *confrère*, in that his engines do not suffer from severe road-vibration or the strains due to traffic blocks, hills, etc.

In the ignition and carburation systems a great improvement has recently been made in internal combustion engines. One can, of course, use a microscopic cell, *i.e.*, accumulator, and a midget coil, weighing together less than a quarter of those we had to employ three or four years ago. Or if high tension magneto is preferred, there are several makes lately put on the market in which weight is considerably reduced. The fuel feed apparatus is another point, too, where much has been, and can still be, done in reducing weight without impairing efficiency. That system in which the petrol is injected direct into the combustion chamber once found a good deal of support, but while certainly having the advantage of lightness, it does not seem to give good results in practice. And even where an atomiser or other external carburetting mechanism is employed, weight can be reduced considerably, both directly and indirectly. By the latter term I mean that, owing to increased efficiency of this agent, a quantity of fuel will go further, thus reducing the dead weight carried.

But by this time I have reached my second qualification, that of efficiency, which is, so to speak, the twin handmaiden of lightness. If one does nothing more than merely lessening an engine's *avoirdupois* one is decreasing the dead weight carried, which means a saving of power. But much more can be done, for it is possible with the minimum practical weight of engine and incidentals to obtain by careful design a considerably increased output. The two factors are inter-connected to this degree, that, for a particular number of lb. weight, we can extract so many B.H.P., avoiding on the one hand such faulty design as

would lead to distortion or early breakdown, or, on the other, impairing the power by disturbing some qualifying factor.

I have already remarked that the ratio between weight and power is lessened by increasing the number of cylinders. Since the majority of aëronautical engines work on the Otto, Beau de Rochas, or four-stroke cycle only, it follows that there is one power stroke followed by three so-called "idle" ones per cylinder. It is for this reason that the single cylinder engine has gone out of fashion for motor cars, and for most of the higher powered motor cycles as well; the strong impulse through 180°, followed by the negative work of exhausting, inducting, and compressing through the subsequent 540°, giving rise to what is known in common parlance as "thumping." But when four cylinders, firing in sequence, are used, not only is a uniform turning movement obtained, so that the dot-and-go-one effect practically disappears, but also the total weight of pistons, connecting rods, crank axle, and fly wheel is much reduced. And as the number of cylinders is increased these virtues grow in proportion till we now have water-cooled engines weighing as little as 6 lbs. or so, per B.H.P., as against their not very ancient predecessors whose weight-power ratio was as much, at times, as 20 and 25 to 1. Further, in multi-cylinders it has also been found possible to dispense with fly wheels, no inconsiderable gain in itself, owing to the good balancing effect obtained when 6, 7, 8, or more power units are rigidly connected as one motor.

Of the three great incidentals, the lubrication, carburation, and cooling system, the former lends itself least of all, perhaps, to treatment with a view to weight reduction. Since an aëroplanist has not time to attend to such details of engine control during actual flight, automatic lubrication is a *sine qua non*, hence our efforts should be concentrated on evolving mechanism which shall be as light and automatic as possible. Therefore we should make reservoirs of light metal as well as reducing their capacity to what is just sufficient for the trip, and, in addition, placing them as close to the motor as possible, so that only short feed pipes are necessary. If a force pump is used for the lubrication it, too, should be as small and light as can be managed without impairing its efficiency.

In regard to lubrication it is advisable to exercise great care in selecting an oil for an aëronautical engine. In a paper read recently by Mr. J. W. G. Brooker, a compound oil was said to be the best kind, one, that is, in which pure hydrocarbons are blended with a fatty oil, the former usually predominating. Whatever the nature of the oil used, it must be able to withstand the high temperature; and that there is a vast difference in the way various brands behave is easily seen by a simple test. There is also the more reason, too, for only using the very best brand obtainable, for not only does it prevent gumming of the valves and a deposit of carbon on the piston heads, with the consequent pre-ignition of the charge, but, in addition, it lasts an extraordinarily long time. A friend of mine has recently carried out tests extending over last summer, on a motor car with what is known as a "Four-Inch" engine. During the last Isle of Man race several cars of this type were stated to have developed 90 or 100 h.p., yet my friend ran several thousand miles on as little as one gallon of lubricating oil to each 1,000 miles. The makers, needless to say, were on tenter hooks when he told them what he was doing, but expressed their astonishment at the perfect state of the engine when it was taken down a few days ago. In view of this, aëronauts will do well to pay special attention to lubrication.

When we turn to carburation a great field lies before us. Not that we can do much here in regard to lessening weight, for modern spray carburettors are remarkably light; so much so, too, that it seems to me very questionable to dispense with them in favour of injecting the fuel direct into the combustion chamber. At the most, the gain in this case is trivial; simply the weight of the carburettor and induction pipes, and possibly other pipes conveying hot water or exhaust gases to the heating chamber. Moreover, the results given by fuel injection are not, on the whole, good enough to warrant its adoption for aëronautical engines. This method was tried in the early days of motor cars, but is now never heard of, with the exception of one or two American automobiles, but in this case any sign

of overheating can be dealt with at once. The system has been used also on one of the Antoinette aëronautical motors, but the firm are now, I understand, fitting a carburettor to the other model. Personally, I am against fuel injection, since the liquid cannot possibly be atomised properly, while it is effectually prevented from diffusing through the air in the combustion chamber, owing to the infinitesimally short period that exists between its entry and its discharge through the exhaust valve. Knowing as we do that the diffusion of gases in the atmosphere is, at the best, a leisurely process even in the case of hydrogen, it is obvious that when a fuel is introduced neat into an engine there must be an enormous waste. Of course it burns, undergoing combustion of a sort, but the process is very imperfect and results in the discharge of unoxygenised petrol through the exhaust valves, and in a carbonaceous deposit on the piston heads, combustion chamber faces, and the sparking plug points. Soon, too, we find the engine "overheating," to use a popular term, which leads to knocking, pre-ignition, and loss of power. Moreover, the rise in temperature is so pronounced as to cause the residual gases to expand enormously, which prevents the ingress of a full charge of fresh air, as well as weakening the combustible material with inert gases left in the cylinder. The falling off in power due to this cause leads to the operator—where he has the chance—giving the motor a larger supply of fuel, which, of course, only makes matters worse. In my own experience I have found the falling off in power under these conditions to amount to as much as 20 per cent. of the normal B.H.P. while, what is worse, the engine can only run at a very high speed, which means it has to be run light—for when under load it bids fair to knock itself to pieces. At the best of times the fuel efficiency of light internal combustion engines is low enough already, and if we are going to decrease it still more by such crude methods as fuel injection, we increase the weight that must be carried as well as running up the expenses enormously.

If one uses a good type of carburettor the results will be very satisfactory, provided, of course, that it is insulated from vibration, and unaffected by the angle through which a flying machine may turn. There is one type, for instance, in which the spraying jet is in the centre of the float. The level of the fuel is thus but little affected when the carburettor is inclined. Or, again, one can easily so arrange things that the carburettor remains vertical, say up to an angle of 25°, flexible connections being, of course, used between it and the fuel reservoir and engines. Since an aërial motor runs at a much more uniform speed than a car engine, there is really little need of carburettor control by hand. Provided it gives a good mixture, the carburettor might be left to look after itself, which, in fact, it is quite capable of doing as long as it is kept at a certain temperature and the fuel is free from foreign bodies. One need not trouble about fuel control at the jet, provided a good automatic system regulates the air supply. Of the latter there are several types in vogue, one of the best, in my opinion, being the Grouvelle and Arquembourg, in which the air supply is regulated by a series of metal balls of different weights.

Another of what may be termed the incidentals of the motor is the cooling system. Possibly I need not do more here than just mention that the temperature during the early part of the explosion stroke may be as high as 3,500° Fahr., though probably it is not greater than two-thirds of this in high speed engines, as the initial compression pressure falls off considerably, owing to wire-drawing of the gases in the induction pipes and inlet ports. But even a temperature of 2,000° Fahr. is too high for such a delicate piece of mechanism as a light motor of the kind we are considering. It gives rise to trouble with the lubrication and is likely to cause warping of the valve heads or stems, or even distortion of the cylinders. Some method of lowering the temperature is, therefore, essential even if we merely wish to avoid damaging the engine, and are indifferent to its efficiency. And here we are brought face to face with two great alternative systems—air-cooling and water-cooling. Each of these has its ardent adherents, and each has its drawbacks. When air is used for cooling an engine it must pass over the cylinder heads with a certain velocity before it is of any use.

This, of course, absorbs power—how much, depends a good deal on the system followed. On the other hand, water-cooling means a considerable increase in the weight of the engine, as the combustion chamber, at least, must have a double wall or external casing, with piping for the flow and return, while a radiator and reservoir are also required. In other words, with air-cooling we get lightness at the expense of power, while with water-cooling we obtain power, but handicap ourselves with increased weight.

The respective claims of air and water cooling are very interesting, and also difficult to compare fairly. Cooling by air draught was a feature of early automobile engines, being efficient enough as long as the power did not exceed 2½-h.p. or so. Some modern motor bicycles have air-cooled engines of 6 or 8 h.p.—two cylinders usually being used—but they are very speedy, doing 50 miles or so an hour, and, therefore, assist in their own cooling. But as the power increases, the speed, whether of motor car, motor bicycle, or flying machine, does not do so in anything like the same proportion, and so we find that air-cooling has proved unsuitable in all but exceptional instances. A fan, driven by the engine, and directing a stream of cool air on the combustion heads, has a good deal to recommend it, particularly if the fuel is treated in a scientific manner, and the speed, relative to that of the atmosphere, is at least 20 miles an hour. Better still is the forced draught system, such as is used in some American cars like the Frayer-Miller. In one that I examined recently a strong stream of air is forced by a centrifugal pump through a chamber over and around the combustion heads and valve pockets, and discharged at the rear of the engine. A two-ton lorry of this type certainly gave very good results recently, and the engine never showed a sign of knocking during a lengthy trial over hilly roads. Air-cooling is quite feasible when the engine is of the multicylinder type, is fitted with a good carburetting system, and has some such arrangement as a forced draught. But the fan or pump must be suitable, a point of which the importance is not altogether realised. On the other hand, an air-cooled engine rarely, if ever, gives off as much B.H.P. during continuous use as its water-cooled rival. Yet the latter system, while making an engine more efficient, has the drawback of increasing its weight and introducing fresh complications into the mechanism. As I have already remarked, water-cooling means an increase of weight, since piping, a reservoir, and radiator are required. The reservoir and radiator may be combined, or the piping itself can be extended so as to suffice without either of these, as was done in one of the Antoinette aëroplanes exhibited at the recent Paris Salon. In this case numerous lengths of small aluminium pipes were used, and said to weigh only a few pounds, as well as to be very efficient. But in addition to their weight, however little, we must add that of the water used for cooling. As the average allowance for motor cars—as small as is found practicable, by the way—is about 1 or 2 lbs. per h.p., we cannot safely go much outside this limit. Hence we are bound to carry as dead weight ½ cwt. of water for an engine of 50-h.p. There is, I believe, a very efficient radiator just put on the market which, while only requiring about one gallon of water for an engine of 20-h.p., gives great satisfaction. If it proves practical it will be very useful for aëronautical engines.

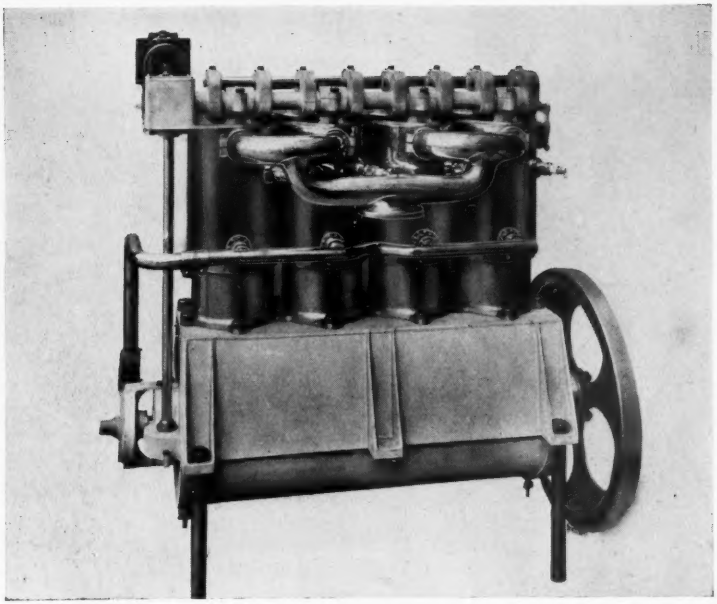
Another point we have to remember, too, when considering water-cooling, is that we must either have a pump to assist the water to flow through the engine, or, if thermo-syphon or natural cooling is adopted, the quantity of water must be greater, either of which has an appreciable effect upon our total estimate. The pump absorbs power and may cause trouble by leaking or breaking, though the latter *contretemps* is not often heard of to-day.

There is a third method, little heard of, it is true, yet none the less very effective. It is what we might term internal cooling, the combustion temperature being lowered by admitting some agent such as water on the explosion stroke, and which, by reason of the change of state it undergoes, absorbs a good deal of heat. Having experimented on this point for six or seven years, I am convinced that, properly applied, water injection is of great value to high speed internal combustion engines, especially where lightness is desirable. The same idea has

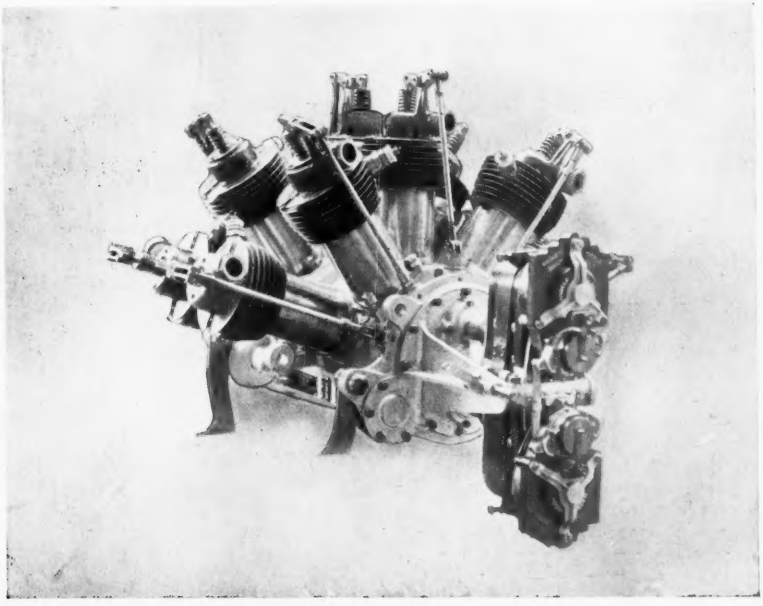
been carried out for some years on slow-running engines such as the Gardner heavy oil motors, but its claims are apparently overlooked, or thought to be merely adding to an engine's complication by automobile engineers. Yet internal cooling is really quite simple, though I do not suppose aëronauts would care about the method followed some years ago in the Banki engine. In this case water was admitted through a special valve during the combustion stroke, a system, however, which is neither simple nor desirable. My own plan is to admit water to the inlet pipe during the induction stroke, *i.e.*, allowing the engine to suck it in with the fuel, when, of course, it is flashed into steam during the explosion stroke. The effect is to cure the harsh knocking sound one so often hears in an overheated engine, and, at the same time, to improve the indicator curve. Instead of the power falling off rapidly on this stroke—in the majority of light internal combustion engines the most effective part is the first two-sevenths—the piston receives more of a prolonged "push," being, indeed, in a sense, steam driven. Personally, I did not find any marked increase in power at high engine speeds when using the water injection, but I did find a vast improvement in other ways. For instance, there was greater economy both in regard to fuel and lubricating oil. Then, again, an air-cooled engine so treated can be kept running at full speed under load without the power falling off as is usually the case in this type after the first ten minutes or so. That they do so is generally acknowledged. A well-known manufacturer of light motors, exhibiting at the recent Paris Aëro Salon, even went so far as to admit to me that his air-cooled engines gave their nominal output for 10-15 minutes, but what happened after that he did not care to say. Hence the need for something more efficient. Messrs. Crossley made some interesting experiments some time back with internal cooling of this kind, and found they could use a compression as high as 200 lbs. per square inch without signs of pre-ignition. The M.E.P., too, worked out to 91.44 lbs. per square inch, and the thermal efficiency to 37.43 per cent. on the I.H.P. That these figures show the value of water injection can be seen when we recollect that very few engines exceed 65-80 lbs. compression, and then mostly in theory, as, under high speed-running conditions, it falls off considerably.

Something similar to the results of the Crossley experiment was found with the Banki oil engine. In 1900 one of these motors was the subject of a test of this kind, and a compression of 16½ atmospheres, *i.e.*, 240 lbs. or so per square inch, was quite feasible. The heat efficiency was 25 per cent., that of the average engine being about 20 (Spooner). In my own case I found that the quantity of water that gave the best results when introduced *viâ* the induction pipe was approximately 1.85 oz. per minute for an engine of 30-B.H.P. The apparatus is very simple, being merely a small nozzle projecting into the induction pipe and coupled by a short length of small-bore rubber tubing to a reservoir. The whole need not weigh more than a few ounces, while the cost is negligible, and its action automatic. The reason one can be certain that water admitted into an inlet pipe will enter the engine is that the depression or suction there at high engine speeds is considerable. For example, a four-cylinder engine which was run at 800 r.p.m. induced a suctional effect at the throttle—when the throttle was full open—equal to nearly 2½ inches of water. When the engine was accelerated to 1,040 r.p.m. the suctional pressure was increased by an inch. 1,200 r.p.m. gave a suction of 4½ inches of water on top gear, and as much as 6 on second. It is clear, then, that the velocity of the gases passing through the induction pipes under these conditions is sufficient to carry along a fine stream of water such as that issuing from an orifice of less than 2 mm. in diameter.

Another device which makes air-cooling possible for high powered engines is the auxiliary exhaust port. Small openings are made in the cylinder walls, which are just uncovered by the pistons at the end of their downward stroke, which has the effect of allowing the hot gases to get away easily. Two engines I experimented with kept much cooler, I found, an annoying knock, due to persistent overheating, disappearing completely in one case. As I published my experience with exhaust ports some years



"Aster" Motor



"R.E.P." Motor

ago, I need not do more here than briefly summarise the result. One I have already mentioned, the prevention of overheating. Another was to increase the number of revolutions per minute by 600-800, a third being an increase of torque by 12-15 per cent. at low engine speeds—say 400 or 500 per minute. The best shape for the port was, I found, rectangular, the length, in the line of piston travel, being not more than 18 per cent. of the stroke—where this did not greatly exceed the bore. The width of the port might be 15 or 17 mm., but more than this was not advisable, as the ends of the piston rings are liable to catch in them and be broken off. Provision must, of course, be made against loss of lubricating oil, as it is blown out with the exhaust gases; also against taking in fresh air on the induction stroke, which is liable to upset the mixture. This, however, is a simple matter and is overcome satisfactorily in the Franklin engine, in which a valve is fitted to the auxiliary port.

I will conclude this paper with a brief reference to some of the leading types of aëronautical engines. Among the newcomers are two manufactured by the Wolseley Company, and exhibited at the present Aëro Show at Olympia. One is of the eight-cylinder V type, of 95 mm. bore and 125 mm. stroke. A float feed and spray carburettor is mounted in the centre of the engine to ensure short induction pipes and equal fuel distribution to the cylinders. Cooling is by water on the thermo syphon system, the engine pockets holding 1½ gallon. Developing 50-h.p. at 13,500 r.p.m. the engine weighs 400 lbs. or less, giving a weight-power ratio of 8 to 1.

The second Wolseley engine also has eight cylinders, but vertical in this case. Of a bore and stroke of 162 mm. and 175 mm. this engine gives 180-h.p. at 6,000 r.p.m., its weight-power ratio being about 9 to 1.

The Aster Company are showing an interesting engine which they are manufacturing in accordance with Green's patent. There are four separately cast cylinders the water jackets of which can be easily detached. The inlet and exhaust valves are operated by a cam-shaft, driven by bevel gearing off a vertical shaft placed centrally between the four cylinders. Lubrication is effected by a pump in the base chamber. Pump-driven water circulation and H.T. magneto are included. An interesting feature of this motor is the method of attaching the cylinders to the crank shaft bearings. For this purpose columns are used through which holes are drilled, the bolts securing the bases of the cylinders passing through them.

Perhaps the best known light engine is the Antoinette, till lately handled by the Adams Company, of New Bond Street. Manufactured in both air-cooled and water-cooled types it has been remarkably satisfactory and reliable, though where a little extra weight is of no moment the latter is preferable. Designed in neat units, of eight cylinders, in rows of four, set V-fashion, without a fly wheel, it can be coupled up so as to make motors having sixteen, twenty-four, and thirty-two cylinders if desired. In the usual eight-cylinder form it develops either 24-h.p. or 50-h.p., according to size. It can be used with a carburettor, though, as a rule, this has generally been dispensed with, the petrol being pumped direct into the combustion chambers. When this plan is followed several pounds weight are saved, but it is not so satisfactory, and is gradually being given up. The 24-h.p. water-cooled Antoinette weighs 115 lbs., without carburettor or ignition apparatus, averaging nearly 5 lbs. per horse-power. The larger size scores somewhat on this point, reducing the weight-power ratio by something like 20 per cent. The usual ignition is high-tension multiple trembler coil, accumulators, and distributor. The air-cooled Antoinette is said to weigh about 2½ lbs. per horse-power.

Light and powerful engines are now made by the Bayard Clement Company, which has recently introduced them for purposes where weight-saving is essential. The best model is the six-cylinder one, giving 170-h.p. at 1,200 revolutions per minute, its weight being about 400 kilogrammes, or 880 lbs. This works out to about 5 lbs. per horse-power. The bore and stroke are 155 mm. and 185 mm., and the valve-gearing is of the overhead type. The engine is water-cooled, the jackets being of copper and of large capacity. The firm also makes a four-cylinder model of 120-h.p., having a bore and stroke of 168 mm. and 160 mm., and weighing 748 lbs., or, roughly, 6 lbs. per

horse-power. In the larger model the cylinders radiate in a circle from the crank-shaft, which is made in two parts, bolted together, and running in ball bearings. No fly wheel is used, accurate balance weights in the crank-case taking its place.

Another newcomer is the E.N.V., which has eight cylinders set in two rows of four at right angles to each other. Known as the V type, this arrangement is followed by the majority of light engine designers, including the Antoinette, Fiat, Jap, Pipe, and Renault. Of 90-h.p., the E.N.V. has a bore and stroke of 100 mm. and 110 mm., and is water-cooled, neat copper jackets giving it an attractive appearance. The crank-shaft is hollow and has three bearings, a single cam-shaft operating the whole of the sixteen valves. Its weight is doubtful, no information being forthcoming on this point; but, judging from appearances, it is about 5 lbs. or so per horse-power.

Another efficient water-cooled engine is the Gobron-Brillié, now pretty well known to us on this side of the Channel, as it has been exhibited more than once at Olympia. It is of particular interest, as it has two pistons in each cylinder, which move in opposite directions during the explosion stroke. One model is of the four-cylinder vertical type, but a later one, the light-weight, with eight arranged in pairs in the form of a St. Andrew's cross, has been recently introduced. This engine is remarkably light, for, including the water used for cooling, two magnetos, and the carburettor system, it only weighs 325 lbs. As it develops 80-h.p. at 1,400 revolutions per minute, it gives the very useful weight-power ratio of four to one. A peculiar feature is that it has no valve gear in the ordinary sense, a neat and compact system of rockers doing duty instead.

Another air-cooled engine that runs the Antoinette very close is the new eight-cylinder Fiat. Estimated to give 50-h.p. at full speed, it weighs 60 kilogrammes, giving an average of about 2½ lbs. per horse-power. Overhead valves, detachable combustion heads, and copper water-jackets are used. This motor, however, looks so small that, perhaps, 35-40-h.p. would be a more accurate estimate.

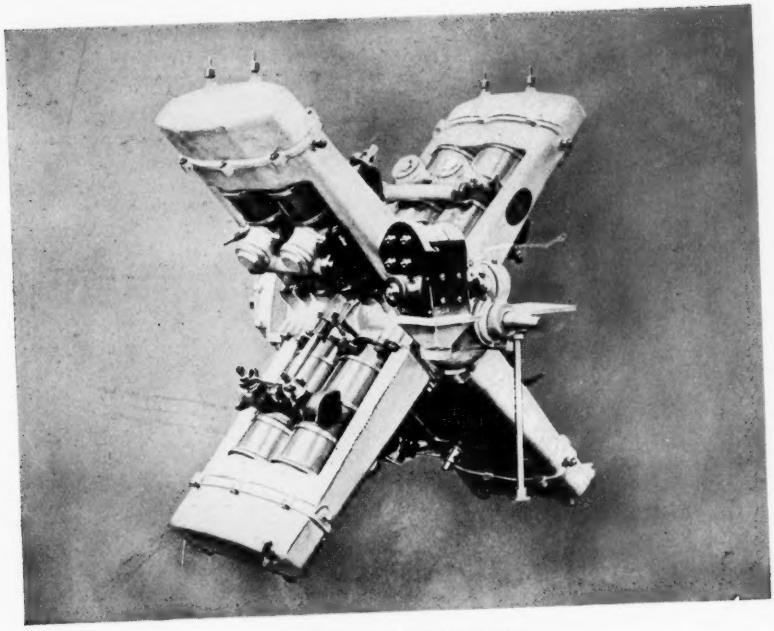
An air-cooled engine of quite another type is the eight-cylinder Farcot, the cylinders of which are arranged in a horizontal circle around the crank-case. There are two throws in the crank-shaft, half the cylinders working on one and half on the other, the alternate cylinders being slightly staggered. A model of this engine was shown at the last Paris Salon, and was said to develop 75-h.p., and to weigh 220 lbs. This gives about 3 lbs. per horse-power without the magneto or carburettor.

An engine which might be suitable for aëroplanes is the new model made by the Gnome Company. It is peculiar in having seven cylinders, the whole revolving round a fixed crank-shaft, the draught caused by the motion being relied upon to keep them cool. The bore and stroke are 110 mm. and 120 mm., and the power 50-h.p. at 1,200 revolutions per minute. Including the fittings, the weight works out to 105 lbs., or slightly more than 3 lbs. per horse-power.

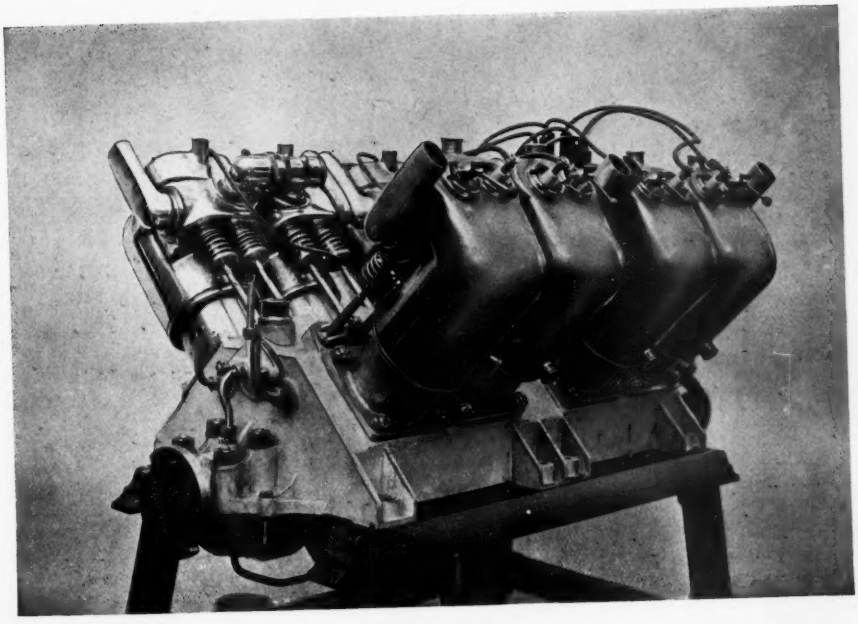
An English firm who have for some years devoted much attention to light air and water cooled engines is the Jap Company. They have recently gone one better by producing an extremely neat air-cooled motor with eight cylinders set V-fashion. Large circular fins pierced with numerous holes surround each combustion head, forming a useful cooling system. Of a bore and stroke of 85 mm. and 95 mm. the engine develops 30-35-h.p. at 1,000 revolutions per minute, and weighs 85 kilogrammes. This works out at about 5½ lbs. per horse-power.

Belgium contributes a good light-weight air-cooled engine in the new 70-h.p. Pipe, and also of the eight-cylinder V type. With a bore and stroke of 100 mm., and light reciprocating parts, it can turn at 1,500 revolutions per minute, at which speed it develops full power. The weight is stated to be 130 kilogrammes, equal to 4 lbs. per horse-power. An ingenious system of cooling is found in this motor, the radiating fins, which are longitudinal, being covered with a light aluminium jacket. The chambers thus formed are connected with a larger one containing a centrifugal fan driven by the engine, which forces a powerful draught over the cylinders. Neat concentric valves, operated by overhead tappets, a carburettor, and magneto ignition are used.

The well-known French firm of MM.



"Gobron" 80-H.P. Motor



"E.N.V." Motor

Renault et Cie. are manufacturing a light-weight engine of 50-60-h.p. A model was exhibited at the last Paris Salon, and looked both efficient and durable. Like most of its competitors, it also has eight air-cooled cylinders, set V-fashion. It weighs 375 lbs., which works out to 6 lbs. or so per horse-power, and it is cooled by forced air draught, a fan in front of the motor driving air on to the combustion heads and thence between the flanges. This firm are also exhibiting at the present Aëro Show at Olympia.

A very interesting aëronautical engine is the Dutheil Chalmers, on view at Olympia at the present time. Made in various types, the particular model to which I am referring has six cylinders, set in threes, opposed to each other. Developing 60-h.p., its weight is alleged to be 170 kilogrammes, or about 370 lbs. A fly wheel is fitted, but of very light construction, consisting of a narrow rim of not more than ¼-inch section, and tangent wire spokes. There is also a very light engine at Olympia in the Miesse, which is said to weigh only 245 lbs. while developing 100-h.p.

Another interesting motor is the air-cooled Adams-Farwell. Of the revolving type, it has five cylinders in the same plane, the bases of which are arranged round a common centre. The cylinders are bolted together and revolve "solid" round the centre of the crank-shaft, cooling themselves by their movement through the air. A single magneto will, it is claimed, fire all the cylinders, but the standard ignition is a trembler coil and a storage battery. It is made in two sizes—36-h.p. and 63-h.p., the respective weights per h.p. being 2.7 lbs. and 4 lbs. The valves are closed by centrifugal force instead of the usual coiled springs and opened by a single cam. The crank-shaft has a single throw, and in the smaller model weighs 4½ lbs.

No survey of aëronautical engines could be complete without a reference to the clever steam engine constructed by Sir Hiram Maxim for use with his aëroplane. Of extraordinary lightness for its power it is a marvel of ingenuity, yet none the less was so handicapped by the weight of the boiler and other appurtenances as to be unsuitable for the purpose. The engine was of the compound type, the area of the H.P. piston being 20 square inches, and that of the L.P. 50.26 square inches. It was estimated to give off 363 horse-power with a steam pressure of 320 lbs. per square inch. When both cylinders were driven by live steam the output reached the high figures of 500-h.p., showing that as far as the engine itself is concerned, its weight-power ratio is far in advance of its rivals.

To sum up, our aim should be to strive after the ideal, which includes the four points I have mentioned, not forgetting accessibility, laying, however, particular stress on automaticity. That is, engines used in flying machines should be able to run for several hours without needing attention. It is imperative, then, that the cooling, lubrication and carburation should be automatic, the ignition, too, being preferably governed so as to suit the engine speed. That we have much to perfect yet is seen from the majority of trips made by flying machines, the cause of an interrupted flight being nearly always found in the inconsistent working of the motor.

Major BADEN-POWELL: Has any gentleman any remarks to make or any questions to ask on this paper? If no gentleman has any remark to make I think that all we can do is to thank Mr. McKinney for his paper. I might say myself—I generally have a way on these occasions of getting up and talking about myself, which I do not intend to do, and hope I may be excused, but it so happens that Mr. McKinney referred to the system of drilling holes through the cylinder to let the exhaust gases out quicker—I made a little engine some years ago now, and I adopted this system, which struck me as being a very good one. At the time I did not know that other people had been doing it, but I find it is not unusual to drill little holes through the cylinder just at the point where the piston comes to its very lowest so as to exhaust the gases straight out, and I may mention that the Wright Brothers, in their machine of which you saw a picture, have also adopted that same system. Mr. McKinney was also saying about the power that their engine gave. Mr. Wilbur Wright told me himself that the engine was originally designed to give 30-horse power, and that it gave out 30-

horse power on the first tests that they had with it, but when they brought it over to France, and tried it again there, they never could get more than 22-horse power. We are very much obliged to Mr. McKinney for coming here this evening and reading this technical paper on the subject of motors suitable for aërial work, because that is one of the most important questions which we have to decide. We know how very much does depend upon the motor. Very often the machine itself will go quite well enough, but we know from past experience of the last few years how continually the motors have failed. I will, therefore, ask you to accord your vote of thanks to Mr McKinney for his paper in the usual way. (Applause.)

Mr. A. J. McKENNEY: I am very much obliged to you for your kind reception of me to-night. I think my paper is a little incomplete. I meant to have dwelt rather more on the need for the automaticity, particularly of the aëroplane engine; however, it is too late for that now. Thank you very much indeed. (Applause.)

Major BADEN-POWELL: I will now call on Mr. Weiss to read the next paper.

Low Power v. High Power Machines

By JOSÉ WEISS

We know that the work required to impart to a body any given speed amounts to a number of foot-pounds equal to one-half the produce of the mass of the body by the square of that speed.

I am quoting this elementary principle because it brings home to us very clearly that the very first condition required for raising an aëroplane, viz., its passage from standstill to flight speed, is purely a question of foot-pounds. No aëroplane can ever be raised (that is, in calm air) until the full number of foot-pounds enacted by the principle just quoted have been expended, and it matters little how this is brought about, either by a falling weight or by running the machine down an inclined plane, or simply by the mere power of the engine.

But what I want to emphasise is that the above principle is only theoretical, and that it does not include the very important additional number of foot-pounds required to overcome the friction on the ground, which depends entirely on the nature of that ground. So that a well-made machine, having ample power to fly, but depending only on its engine for raising itself, although quite capable of doing so on a good surface, might be utterly helpless on a bad one, in exactly the same manner as a cyclist, who could get up a pace of 25 miles on an asphalt track in a few seconds, could not reach a speed of ten on a ploughed field if he were to try the whole day. If, for instance, the Wright machine was placed on a light trolley fitted with good bicycle wheels, and if that trolley was running on asphalt, the falling weight and the rail could quite well be dispensed with, and the machine, in calm air, would leave the ground after a run of about 70 yards. Let us say the machine weighs, roughly, 1,000 lbs. and the speed, as taken from the published records, is 60 feet per second and we have for

$$\frac{W v^2}{2 g} \quad \frac{1{,}000 \times 60^2}{64} = 56{,}250 \text{ foot-pounds.}$$

Taking, then, the 24-h.p. motor to yield an actual efficiency of no more than two-thirds, or 16-h.p., the time required for developing the above 56,250 foot-pounds is

$$\frac{56{,}250}{16 \times 550} = 6.4 \text{ seconds,}$$

and the space covered

$$6.4 \times 30 = 192 \text{ feet.}$$

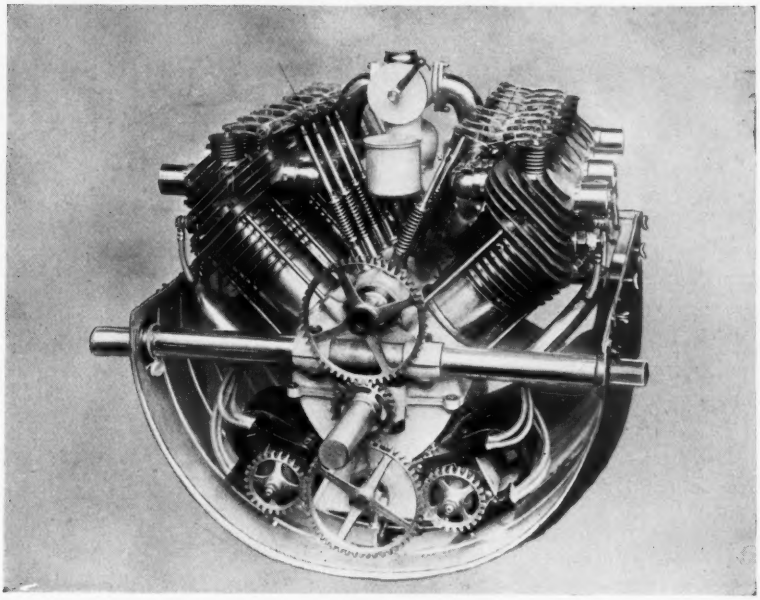
By using the falling weight, viz., 1,500 lbs. falling 20 feet, and supplying 30,000 foot-pounds—the work left for the engine is reduced to 26,250 foot-pounds, which gives for time

$$\frac{26{,}250}{16 \times 550} = 3 \text{ seconds,}$$

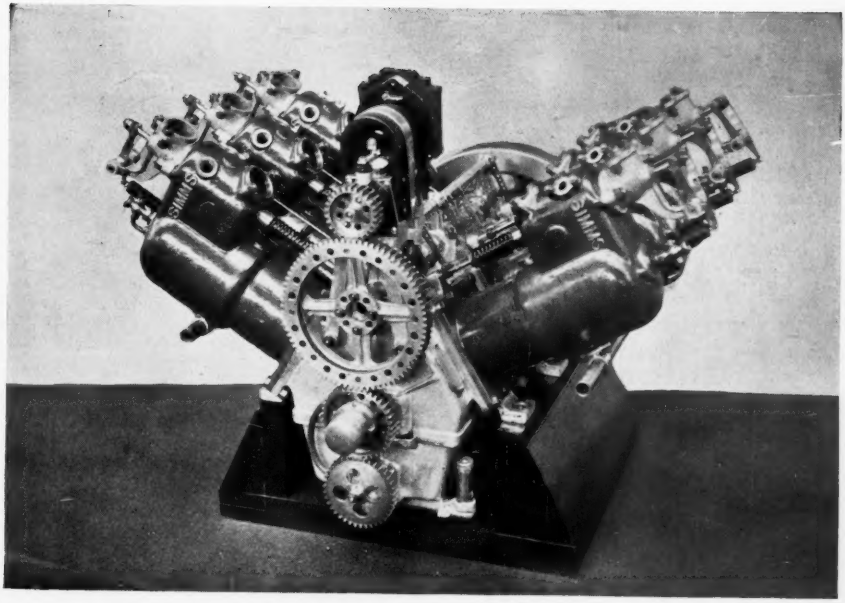
and for space $3 \times 30 = 90$ feet.

This allows nothing for frictional loss or air resistance, and still Wilbur Wright manages very well with his 70 feet rail, showing that my figures for a start without the weights are well on the right side. In the total absence of wind, however, the shortness of the rail must cause, and does cause, an occasional mis-start.

It is very clear that there would be no



"F.I.A.T." Motor



Aero Motor Co.: 50-H.P. Motor

need for launching appliances of any sort if we had for the start a perfectly smooth and hard surface on which the necessary speed could be reached with a minimum of frictional loss.

Now the question which presents itself is this: Do we want a machine capable of rising unassisted from any rough surface? The Voisin type is of this class, which I will call the high power type. Or do we want a lighter machine requiring a minimum of power, but capable of rising from a perfect surface only? The Brothers Wright flyer belongs to this second class, which I will call the low power type. Both are feasible; it is for ourselves to know what we want to do.

Am I right in saying that one of the greatest drawbacks of the first class of machine is that, in order to overcome the initial resistance, they require a great stationary thrust which can only be obtained by a short pitch at high rotary speed? This involves direct coupling, and, consequently, small diameter propellers, giving a great thrust at the start, but a reduced one in flight on account of the slip. Hence a considerable waste of power. If, on the other hand, the starting ground be such as to cause very little resistance, we can use, by gearing down, large, long-pitched propellers with low rotary speed which give comparatively little thrust at standstill, but become highly efficient as soon as the machine is under way. This difference is probably the principal factor which enables the Wright Brothers to negotiate two passengers with only 25-h.p. just as easily as Voisin does with 50-h.p.

I pointed out in a paper read before this Society last year that the extreme difficulty which is encountered by all aviators in finding a suitable place for their experiments is an ample proof that, when we come to real journeys through the air from one city to another, there will be much difficulty of finding a place fit for landing until suitable aërogarages or depôts have sprung into existence, having a suitable ground to land and to re-start, and sheds to house the machines. We must remember that, barring roads and streets which are obviously useless, every scrap of land has a landlord whose rights cannot be neglected. This being the case, and since it is quite simple to provide at the stations a suitable smooth surface, the advantage of a machine capable of rising from a rough surface is not so great as might appear at first sight. Even for war purposes it will be much safer for an army to carry with them some light, suitable launching arrangement than to rely on the off-chance of finding a suitable ground. Would it have been possible, for instance, to get off a Voisin machine from the rough veldt in the South African war? From the photos I have seen I should say it was very doubtful. It can be argued that in the case of a breakdown and consequent forced landing, a machine built to ascend only from a specially prepared surface would be stranded. Most probably it would, but the chances of the other class of machine of being better off are very remote. It would depend entirely over what sort of country the breakdown was to occur.

I believe that we should aim in the same direction as the Brothers Wright, that is, towards the low power machine. But we might improve on their cumbersome and somewhat dangerous method of starting by simply providing our experimental grounds and our stations with a perfectly smooth and hard surface, made up of asphalt or cement, or even for economy's sake of a layer of fine cinders thoroughly levelled and firmly rolled down. A circle of, say, 100 yards in diameter would probably be ample for any machine capable of flying at all, and if placed in the centre of the ground this circle would permit of a start in any direction against the wind. This is, after all, not very much more than what is done for the average football or cricket club.

At the present stage of the whole question no new type can be said to be an advance on the existing ones unless it can accomplish the same performance either under greater compactness and simplicity, or with less power, or with a less amount of personal skill. In other words, the advance must be in the direction of greater efficiency of the planes and driving gear, and of more automatic stability. A smooth surface for the start will facilitate efforts in that direction. For instance, if the start can be accomplished under easy conditions, a machine of the Wright type, built strictly for a single passenger, and, therefore, much smaller and lighter than the exist-

ing machines of that type, would only require a very slight increase of efficiency to be accommodated by an ordinary strong cycle motor, and we come in sight of a practical popular flyer. In another direction, although the construction of very large machines would, for lack of experience, be still fraught with considerable difficulty, it takes no great stretch of imagination to conceive a machine made to, say, three times the scale of the present Wilbur Wright flyer, that is, with a span of 120 instead of 40 feet. Such a machine would be a mere mite in size and in cost as compared with the Zeppelin airship, although its capacity would be at least thirty passengers comfortably seated in a roomy and entirely closed carriage. Here, again, the first condition for such a machine is a suitable harbour, but if we suppose the existence of a properly fitted station at each end of the line, what stands in the way of a direct passenger service between Paris and London. I believe that this will be a reality before another three or four years have elapsed.

Ordinary depôts for landing and re-starting need not be very large. By the time we have become experts at driving our machines a clear space of half-a-dozen acres in an open neighbourhood will probably be found quite sufficient, but matters are very different for an experimental field on which to practise and to learn how to ride. For this a very large tract of level and unbroken land is required if accidents are to be avoided. In France nearly all garrison towns possess a huge manœuvring field, which seems to answer the purpose admirably, but in this country such places do not appear to exist, and to the would-be aviator the finding of a suitable place for his experiments is the most vexing of already innumerable difficulties.

Major Baden-Powell: If any gentleman has any questions to ask or any remarks to make we shall be very glad to hear them.

Colonel Stone: I have followed the lecturer with regard to commercial and sporting purposes that 100 yards diameter of asphalt or some smooth surface would enable these low-power engines to carry out the work satisfactorily on the same lines as the Wilbur Wright machines. I should like to ask him what his view is, if he has thought about the subject, as regards machines destined for military purposes for scouting and so on, where it would obviously be impossible to have regular stations with laid out tracts for starting and where, apparently, it would be necessary for the machines to be accompanied by some suitable starting apparatus such as Wilbur Wright employs, whether he thinks it would be better to adopt some system such as Wilbur Wright employs, that is to say, to carry your starting apparatus about with you, or whether, on the other hand, he thinks the development in the future should be more in the direction of perfecting the means of providing machines which would be somewhat independent of the ground which they had to traverse at starting. I think this is a very important question from the military point of view, and, therefore, I shall be very glad if the lecturer could give me some opinion on the subject. (Applause.)

Mr. Jose Weiss: I first take the question from the commercial point of view of general utility. I believe that from that point of view, as I said in my paper, the establishment of these stations will follow naturally. Now, for instance, if we travel through France or anywhere on the Continent we find garages for motor cars have sprung up absolutely in every village, and in the same way it will pay even hotel proprietors to secure a field to attract us when once there is a popular machine on the way which is cheap and a large number of them are about. There is really no great expense attached in establishing one of these stations. The building of a shed—you can get a very large shed for a matter of £100, and to rent a field just outside a town is not a very great expense either, and it is quite easy to roll out a flat bit of land just the same as they do for a cricket club or a football club. When it comes for military purposes it is quite a different matter. War has to be carried out in another country, and you never know in what sort of country you will be, but I think it would take an exceedingly powerful machine to be able to rise on a very short space. It depends entirely what sort of ground you get. Of course, if you have a powerful machine, say one of the Voisin type. Take the South African War; I have not been in South Africa and I don't know what it

is like, but from the photos I have seen it is full of big boulders and a very unequal surface. You could not possibly get up a speed on that sort of surface, and you will never get up an aëroplane unless you get up a speed. Whereas a machine of the Wilbur Wright type will be got off very easily. It is quite easy to carry some sort of weight with you. You can fill the bags wherever you are of earth or stones, that is certain. If you rely on finding a surface on which you can get up a speed of 30 or 40 miles an hour, whatever the speed may be, you will always run the risk of not being able to find it. Of course, we do not know what the future of the aëroplane may be, but one thing is certain, that as long as we go on the aëroplane line no aëroplane can be raised from the ground until you have reached the flying speed, and that speed has to be got up on the ground.

Colonel STONE: Do you think there is any future for military purposes in a combination by which the aëroplane can be raised in the air first of all and then given transversal direction as compared with the use of an apparatus for starting such as Wilbur Wright has?

MR. JOSE WEISS: I should not be very much inclined to pass an opinion on that, because the thing is not invented yet, and it is quite certain that, if you combine a helicoptere with an aëroplane, you get into a vicious circuit, you must have a thrust equal to the weight of your machine, and you may just as well use a balloon. If you want a thrust equal to the weight of the machine you must have a powerful motor and that would be very heavy. The beauty of the aëroplane is that you require a thrust which is only equal to the angle of what the machine gives in gliding. That is, if you have a machine that glides at an angle of 1 in 5, if you have a thrust equal to one-fifth of the weight of your machine it is sufficient to make it glide horizontally. Take the case of Wilbur Wright. If you have a machine that will glide 1 in 10, a thrust of one-tenth of the weight is sufficient, and it is only a question of increasing the efficiency, the gliding efficiency of the machine. If we look at Nature we find that birds can glide and not drop more than one degree, which is about 1 in 50. I have often seen them in absolutely calm air. It is purely a question of efficiency. The wind, instead of falling at any sort of angle, falls at an angle which is practically the horizontal, and, therefore, if it reaches an angle of, say, 1 in 50, a thrust of one-fiftieth of the weight is sufficient to keep them going indefinitely. But as soon as you want to make a machine to be lifted vertically, the only way is to give a thrust which is equal to the weight of your machine, and you get into a vicious circuit.

MR. A. J. MCKINNEY: Am I correct in assuming that Mr. Weiss suggests that we should use the public roads? In case you have that impression may I just remark that I think it would be extremely inadvisable to do so. Lately my motor car has been the subject of certain unwelcome attentions by the police. If they do that to me what on earth would they do if a large cumbersome machine like an aëroplane landed in the public roads?

COL. J. D. FULLERTON, R.E.: I should like to make a few remarks on this subject. I quite agree with what Mr. Weiss said regarding aërial garages, and I do not myself see why there should be any difficulty about them. For sea-ships, large and expensive harbours are built, to ensure their proper starting, housing, when not required for use at sea, etc., and just the same kind of places will be required for air ships. Such ships, if they do not possess private garages, will move about from one public garage to another, pay any necessary charges, and, in fact, use the garages in exactly the same way as sea ships at present use their harbours. The garages themselves need not be of any expensive type; all that is required, is a good large open space such as we have at our experimental ground at Dagenham, and a good starting place, consisting of a well levelled piece of ground laid down in asphalt or cement, or even with road metal, as is done in the case of parade grounds.

An area of about 100 yards by 100 yards should be ample for all requirements, especially if a border, say, 100 to 150 yards wide, of good turf was laid down round the cemented portion of the ground.

As regards the starting of aëroplanes in war, I think that people are apt to make too much of the supposed difficul-

ties in such a case. I do not know whether Col. Stone has been in Afghanistan, but no doubt he has, and I daresay he knows the country about the Bholan Pass, which is, I suppose, as bad a place for starting aëroplanes as could well be found. Suppose, however, a British Army was operating along this line towards Kandahar and the west of Afghanistan. A first base for starting aëroplanes would be set up at Sibi, a second at, say, Quetta, 40 miles or so further west, and future bases could easily be established as found convenient at suitable points along the line of operations. As regards the action of the flying machines themselves, these would fly out from the bases, in all desired directions and return thereto when they had completed their work. It must be recollected that such machines could easily cover distances of from 100 to 200 miles (out and home) in a short day, and that while, no doubt, some would be lost, the greater part would have little or no difficulty in returning to their starting points as soon as they had completed their work.

As regards starting apparatus, I think myself that it is much better for machines to be self-contained and able to rise from the ground with their own power; but, as a matter of fact, there would be little or no difficulty in setting up any starting apparatus considered necessary at the bases above-mentioned.

Colonel Stone: I quite agree with what Colonel Fullerton says. I think that on the frontiers in many places these stations could be established without the slightest difficulty, so that machines which had to start off their own wheels would be able to get up in the air without any trouble, but it opens the door at once to the consideration of machines of two different types, one for offensive and one for defensive scouting. What I had in my mind when I asked the lecturer my question was offensive campaigns in which we couldn't use our own ground and we should have to take our aëroplanes with us and use them in whatever country we found ourselves in, and for that purpose it appears that we should have to use machines of a type which would require a special starting apparatus, because certainly, in Manchuria, for instance, the ground would very seldom be suitable for starting a machine on its own wheels. As regards South Africa, which the lecturer alluded to, there are certainly vast stretches of country on the veldt where, I think, the conditions are far more favourable than anything that Mr. Cody has had to contend with in the neighbourhood of Aldershot. I think Colonel Fullerton has raised a very important point, and that is the establishment of stations on our own frontiers, whether in England or in other parts of the Empire, and there appears to be no reason whatever why we should not establish stations just, as Colonel Fullerton says, on the same lines as we establish our docks and our harbours. In the particular locality that he alluded to, Sibi, there is absolutely no difficulty at all. The natural conditions are quite good enough for anything, and no doubt natural conditions could be found suitable in very many places which would require very little expense to make them quite suitable for the purpose, that is, always assuming, of course, that they are on our defensive frontier, and we use our aëroplanes for scouting into the neighbouring territory and returning to our own base, which is a totally different condition from carrying aëroplanes with an offensive army, and having to leave our base as the army goes along.

Mr. Jose Weiss: I should like to say one thing, I have tried to point out in the paper that both types are feasible. It is for ourselves to know what we want and for what purpose we want them. But I should say that for the civil purpose, that is, for commercial or sporting purpose, we certainly ought to work in the direction of the Brothers Wright, that is, make our machines as low power as possible; make them highly efficient so as to be able to take as little power as we can. The advantage is obvious. If you make a machine that can be accommodated with a small motor, there is, first of all, the immense advantage of a very much reduced price. In the second place you have a much greater margin for petrol; it doesn't consume so much petrol. In the third place you can better afford to use a motor which is a little more in weight in relation to its power, and, consequently, more reliable. When you come to talk of a motor giving 100-h.p. which weighs 220 lbs., such motors

as that are altogether out of proportion—they can never be made to work. You cannot imagine a bulk of metal weighing 220 lbs. to stand the strain of 100-h.p. To me, at least, it seems almost out of the question, whereas if we reduce the power required by increasing the efficiency we are at liberty to use motors far more robust and able to stand much more weight and knocking about. I thank you very much, gentlemen. (Applause.)

Major BADEN-POWELL: It seems to me that this question has been well settled by several gentlemen who have taken part in the very interesting discussion. There is one point that I should like to point out, if I may, about the looking, not so much to the future, when we have got perfect machines, as to the more immediate future, when machines, especially with these engines that we have been talking about, are likely to break down. I want to know what happens, supposing the engine begins to get a little wrong and you want to come down for a few minutes hammering at it, and then it won't do for you to have to get on till you get to the garage, because the chances are you won't get there. (Laughter.) I would also like to mention that we often talk about these flat plains, and it always seems to me that there might be a great advantage in using a bit of natural hill. You would get up much greater speed for a short distance by utilising some mound. I don't say that you have always a hill available just at the spot you want it or facing the right direction, but very often that can be got. And also the ground can very often be improved in a very few minutes by just using a spade over it. For instance, for military purposes you can get some men to come along with spades and dig you out a nice little track for a hundred yards or so. However, those are matters of no great importance. We have heard a very interesting discussion, and I am sure you will join with me in rendering to Mr. Weiss a vote of our hearty thanks for his paper. (Applause.)

The meeting then concluded.

On the Thrust of Propellers

By H. CHATLEY, Esq., B.Sc.

The thrust obtainable from a propeller depends on three variable quantities:

(1) **The revolutions per second (n).**
(2) **The dimensions of the propeller.**
(3) **The slip (s).**

Two further quantities are involved, the Torque (M) and the Power (H), but these are both dependent on the three preceding.

Assuming, in the first place, a constant slip (say, 100 per cent.), and choosing any convenient value for the revolutions, we immediately fix a relation between the power consumed and the torque,

$$H = \frac{M.\ 2\pi n}{550}$$

or

$$M = \frac{550\ H}{2\pi n}$$

but the torque is also dependent on the dimensions and the speed, for it is due to the air resistance which varies as the area of the moving surface and the square of its linear speed, so that we can write, taking constant dimensions,

$$M = Kn^2$$

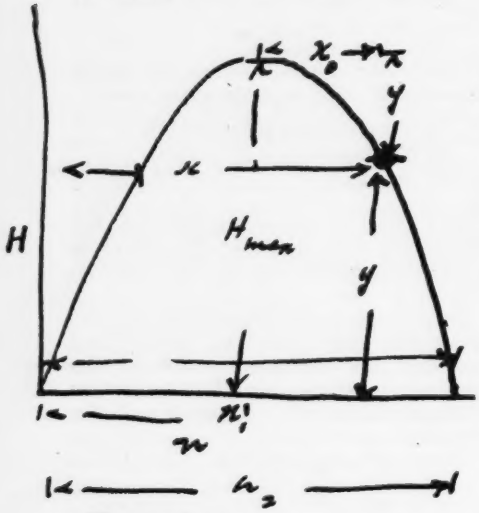
and

$$H = \frac{2\pi K n^3}{550} = an^3 \qquad (1)$$

It must, however, be realised that at a certain speed the motor produces a definite horse power as defined by the "characteristic curve" (power on a revolutions base), so that, unless by coincidence the horse power required by the propeller is the same as that given from the motor, the revolutions will increase or decrease until the two items do agree.

We may deduce an expression for the horse-power from the revolutions on the assumption (which is *frequently* true) that the "characteristic curve" is a parabola, with its vertex passing through the maximum horse-power and the curve crossing the base line at $n=0$, and $n=n_2$ twice the revolutions corresponding to maximum power ($n_2 = 2n_1$).

(It will be understood that the crown only of the curve will enter into most calculations.)



Then we have

$y_0 = mx_0^3$
but $y = H\ max. - y_0$
and $x = n_1 \mp x_0$
so that $\mp x_0 = x - n_1$

$H\ max. = mn_1^2$
$M = \frac{H\ max.}{n_1^2}$

and $x_0^2 = x^2 - 2n_1 x + n_1^2$ and $y_0 = m(x^2 - 2n_1 x + n_1^2)$

so that $y = H\ max. - m(x^2 - 2n_1 x + n_1^2)$

or putting $H = y$, and $n = x$, and $m = \frac{H\ max.}{n_1^2}$

$$H = H\ max. - \frac{H\ max.}{n_1^2}\left(n^2 - 2n_1 n + n_1^2\right)$$

If, now, we equate the two expressions for horse-power

$$\frac{\pi K n^3}{275} = H\ max. - \frac{H\ max.}{n_1^2}\left(n^2 - 2n_1 n + n_1^2\right) \qquad (2)$$

we thereby fix the value of n at which the propeller will naturally run. This is an equation of the third degree

$$\frac{\pi K}{275} n^3 + \frac{H\ max.}{n_1^2} n^2 + \frac{2H\ max.}{n_1} n = 0$$

but reduces naturally (since there is no fourth term) to a quadratic

$$\frac{\pi K}{275} n^2 + \frac{H\ max.}{n_1^2} n + \frac{2\ H\ max.}{n_1} = 0$$

which solves to

$$n = -\frac{137\ H\ max.}{\pi_1 K n^2} \pm \frac{\sqrt{74625\ H\ max.^2 - 2200\ \pi K n_1^3\ H\ max.}}{2\ \pi K n_1^2}$$

$$= \frac{-275\ H\ max. \pm \sqrt{74625\ H\ max.^2 - 2200\ \pi K n_1^3\ H\ max.}}{2\ \pi K n_1^2} \qquad (3)$$

A graphic solution by plotting

$$\frac{2\ \pi K n^3}{550}$$

on the same base as the characteristic will at once show the value of n.

It is thus seen that the revolutions can be expressed in terms of the nominal horse-power (which is equal to or bears a constant ratio to H max.), and a quantity (K) which, when multiplied by n^2 gives the torque under constant slip conditions, and *vice versâ*, we shall expect to find K in terms of n and the nominal horse-power.

The quantity (K) depends on the area and manner in which it is arranged about the axis of rotation. We may obtain a rough idea of its value by studying a fan-bladed propeller. The pitch angle at the circumference of such a propeller is

$$\theta_2 = \tan^{-1}\left(\frac{p}{\pi d}\right)$$

where p is the pitch and d the diameter. Since p will never be more than d we may write for the present purpose

$$\theta_2 = \frac{p}{\pi d}$$

and the pitch angle anywhere $= \frac{p}{2\pi r}$

If there is 100 per cent. slip (*i.e.*, propeller stationary), we may write the normal pressure in any elementary area

$$ap = \frac{r\ \beta\ dr \times v^2 \times \theta^0}{300}$$

or, since $30° = \cdot 52$

$$ap = \frac{2\,r\,\beta\,v^2\,p\,dr}{2\,\pi\,r} = \frac{\beta\,v^2\,p}{\pi}\,dr$$

But $v^2 = 4\,\pi^2 n^2 r^2$

so that we have finally

$$ap = 4\,\beta\pi n^2 p r^2 dr$$

And the total pressure is

$$P = \int_{R_1}^{R_2} 4\beta\pi n^2 p r^2 dr$$

$$= \frac{4}{3}\beta\pi n^2 p\left(R_2^3 - R_1^3\right) \qquad (4)$$

The axial component of this is

$$\frac{4}{3}\beta\pi n^2 p\left(R_2^3 - R_1^3\right)\cos\theta_2$$

or since θ_2 is small

$$\frac{4}{3}\beta\pi n^2 p\left(R_2^3 - R_1^3\right) \qquad (5)$$

The tangential component is

$$\frac{4}{3}\beta\pi n^2 p\left(R_2^3 - R_1^3\right)\sin\theta_2$$

Or if we write $\theta_2 = \sin\theta_2 = \tan\theta_2 = \frac{p}{2\pi R_2}$

$$\frac{2}{3}\beta u^2 p\frac{R_2^3 - R_1^3}{R_2}$$

The axial component is the thrust per blade. The tangential component when multiplied by a suitable radius is the torque. The latter will (disregarding the variation in θ) be the radius of gyration of the blade, so that we have

$$\text{Torque} = \frac{2m}{3}\beta n^2 p\,\frac{R_2^3 - R_1^3}{R_2}\,R_k \qquad (6)$$

where m is the number of blades, and R_k is the radius of gyration. A better value is perhaps obtained by direct integration.

$$ap. = 4\,\beta\pi n^2 p r^2 dr$$

$$r\,ap\sin\theta = 4\,\beta\pi n^2 p r^3\left(\frac{p}{2\pi r}\right)dr$$

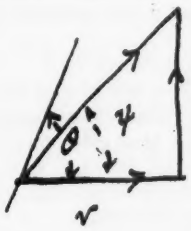
$$= 2\,\beta n^2 p^2 r^2 dr$$

and its integral per blade

$$= \frac{2}{3}\beta n^2 p^2\left(R_2^3 - R_1^3\right)$$

which multiplied by m gives torque. (6a)

We must next inquire as to the effect of slip. If a propeller is advancing axially with a speed of u feet per second, and at the same time the surface is moving with a speed v feet per second, then



the actual motion through the air is made at a speed $\sqrt{u^2 + v^2}$ or v sec. ψ. The angle at which the air impinges on the blade is $\theta - \psi$ so that the pressure on any element of area is

$$dp = \frac{r\beta dr v^2 \times (\theta - \psi)^\circ}{30^\circ}$$

or since $30° = \cdot 52$ radians

$$dp = 2r\beta dr v^2\,(\theta - \psi)$$

n is an independent variable, and $\psi = \tan^{-1}\left(\frac{u}{v}\right)$ and if we make $\psi = \tan\psi$ we may say

$$dp = 2r\beta dr v^2\left(\theta - \frac{u}{v}\right)$$

but $v = 2\pi rn$, and $\theta = \frac{p}{2\pi r}$, so that we have

$$dp = 2\beta r dr\,(2\pi rn)^2\left(\frac{p}{2\pi r} - \frac{u}{2\pi rn}\right)$$

$$= \beta 8\pi^2 r^3 dr\,n^2\left(\frac{np - u}{2\pi rn}\right)$$

$$= \beta 4\pi r^2 dr n\,(np - u)$$

and integrating for the whole blade

$$p = \int_{R_1}^{R_2} 4\pi n\,(np - u)\,r^2 dr$$

$$= \beta\frac{4}{3}\pi n\,(np - u) \times \left(R_2^3 - R_1^3\right) \qquad (7)$$

which differs only from the previous result (with 100 per cent. slip, *i.e.*, u = o) by the term nu.

Reverting to our previous method p and multiplying by $\cos\theta$ we have the axial thrust = p.

To find the torque, we must multiply dp by r sin θ and integrate.

Since we may write

$$\theta = \frac{p}{2\pi r}$$

$$r\sin\theta = \frac{p}{2\pi}, \text{ a constant}$$

so that the integral is simply

$$\frac{2}{3}\beta\,np\,(np - u)\left(R_2^3 - R_1^3\right) \qquad (8)$$

which multiplied by m is the torque.

Hence we have torque

$$= \frac{2}{3}\beta\,np\,(np - u)\left(R_2^3 - R_1^3\right)$$

$$= cnp\,(np - u)\,d$$

where c and d are constant for any one propeller.

Expanding, we have

$$M = cd\,n^2p^2 - cd\,npu$$

or under constant slip conditions

$$M = gn^2 - hn$$

The previous use of K as a constant is thus not justified, so that we must re-write (2) as follows:

$$\frac{(gn^2-hn)\pi n}{275} = H\,max. - \frac{H\,max.}{n_1^2}(n^2 - m_1n + n_1^2)$$

which may be solved graphically or algebraically.

Report on Aërial Level Experiments

By F. DRAPER, Esq.

My object was to make an instrument by which the inclination of an aërodrome could be readily ascertained when in motion.

1. Combinations of two or more levels of the ordinary pattern were tried.

Result.—These were difficult to see and not suitable for very minute movements.

2. Second experiment. Pendulum type.

Result.—This type could be made to indicate any direction, but was difficult to make dead beat.

3. The next type tried was a hollow dish with a small globule of mercury or other liquid, and to indicate the direction, circular lines were set so that each line represented two or more degrees.

Result.—This answered very well, the only disadvantage was to make it dead beat.

4. The next type tried was a hollow dish filled with liquid so that a small bubble indicated the movement, and also lined so that these showed, one, two, or more degrees, according to the distance apart. This type also shows movement in any direction.

Result.—The best so far used, but numerous experiments were made before the correct convex glass could be made. At the finish, I had to make the glass shape myself, and grind the two faces together to make a tight joint.

Numerous tests were made to find the correct size of bubble and the correct liquid to use.

I tried the following: Mercury, glycerine, sperm oil, several mineral oils, paraffin, petrol, alcohol, and various tints of the same liquid. I found the best size of level to be about $3\frac{3}{4}''$ to $4''$ in diameter, anything smaller made it difficult to read.

For night work a small electric lamp could be fitted at the bottom of the glass level, thus making the liquid transparent.

I may say that the types Nos. 3 and 4 are my own design, upon which I first experimented about eighteen months ago.

The photo shows my experimental level, which includes Nos. 3 and 4 types.

Report on Progress Made to February, 1909

By JOSE WEISS, Esq.

I regret that I am unable, up to the present, to report any practical result in the shape of an actual flight.

On the other hand, considerable progress has been made and much experience gained. Five full-size machines in all have now been built, the last one, which is now ready for experiments, embodying all the experience gained by the construction of the others, and this ought to give satisfactory results. Its total weight, including the operator, is about

250 kilogramms. It has a total wing area of 14 m^2, with a span of 11 metres. It is fitted with a 12-h.p., 3-cylinder Anzani motor, driving by chain gear two 1 m 95 propellers, placed towards the rear of the wings and on each side of the motor. A special feature of the mechanical part is the way in which the propellers are mounted on a fixed spindle with ball bearings inside the boss of the propellers, the chain-wheels being bolted on the propellers themselves. The motor thus drives the propellers on exactly the same principle as a bicycle wheel, straight from the motor shaft, with an absolute minimum of friction.

Small difficulties of detail, cropping up almost at every step, especially in the mechanical part of the machine, are the cause of ever-recurring delays. They are, however, gradually being disposed of and it must be remembered that this is practically unavoidable in the production of a machine of an entirely new type, where every detail has to be a complete invention, and especially so when economy has to be a foremost consideration.

There can be little doubt, judging from the beautiful results obtained with large size models, fully loaded, and more especially so with the last models, made quite recently, that as a type of machine, this one must be a distinct advance on any other in existence so far, as soon as we have succeeded in adjusting the motive power in a satisfactory and reliable manner.

Houghton House,
Houghton, Near Arundel,
February 23, 1909.

The Society's Experimental Ground

By MAJOR B. BADEN-POWELL

In December, 1908, a committee was formed with the object of investigating suitable sites on which experiments with aërial machines could be carried out.

It was decided that the necessary conditions must include:

1. Accessibility from London.
2. Open country for some miles.
3. Exposed ground for kite flying as well as sheltered ground for aëroplane experiments.
4. Sloping ground for gliding and models.
5. Large sheet of water for making tests on and over.
6. Possibility of fencing in and keeping private.

The committee made tours all round the environs of London, but soon came to the conclusion that there was no large open space that could be kept at all private, except on the banks of the lower Thames, where many large stretches of marsh land exist. Finally, the neighbourhood of Dagenham Dock was decided upon, as combining many very desirable conditions, and an arrangement was come to with the landlords for the hire of a suitable piece of ground.

The site selected consists of an area of rough ground to the east of the Dock, measuring about half a mile by a quarter of a mile. This is all high ground, well above the river, and can be cleared and levelled as desired. At one corner of this an acre has been enclosed for the sheds and other buildings. To the north of this site extends a flat open piece of country, now cultivated, belonging to the same landlords, and the whole of this ground is enclosed by water, the Thames to the south, Dagenham Breach, a lake averaging 100 yards wide, to the west and north; and a canal to the east. So that the entire area is private property, and can only be entered at three definite entrances. The lake is an important feature of the property, rights having been obtained for members to carry out experiments either with flights over or tests on a fine sheet of clean, fresh water. Two sites bordering on the banks have been acquired for boat houses, etc.

On each side of the ground wide, open marshes extend for many miles, so that long flights will be possible.

The area mostly consists of "made" ground, but *not* refuse heaps (which exist at many other places on the Thames banks). This affords several steep slopes which are likely to prove of use for gliding experiments or trials of models. The high ground is well exposed to all winds and is therefore suitable for kite flying, but there are many spots well sheltered by these steep slopes where other experiments can be conducted out of the wind. Some old railway tracks, formerly used

in "dumping" the earth, may perhaps be available for getting up speed either for testing models or starting aëroplane machines. A private road, some 500 yards long, is also available for running machines along.

As regards the buildings and improvements made or contemplated, there are at present a small "club house," fitted with stove and lavatory, etc., and some small sheds are being erected for the housing of models. Larger sheds for machines are also being put up by individual members, and, if required, the Society will erect some more, to be let out on hire to members. It is also proposed to arrange, as soon as possible, a workshop and laboratory.

The preparation of the ground is rather a difficult matter to decide upon. The committee at first proposed to level down a large piece, perhaps 200 or 300 yards across, and roll it in with cinders, so as to give a good hard surface for starting wheeled machines. So far, however, although five members have announced their intention of at once undertaking experiments, none have expressed a wish to use such a place as suggested, some only proposing to make trials over the water, and some using special starting apparatus. So the ground at present remains in its rough state, except for one acre, which has been cleared and levelled.

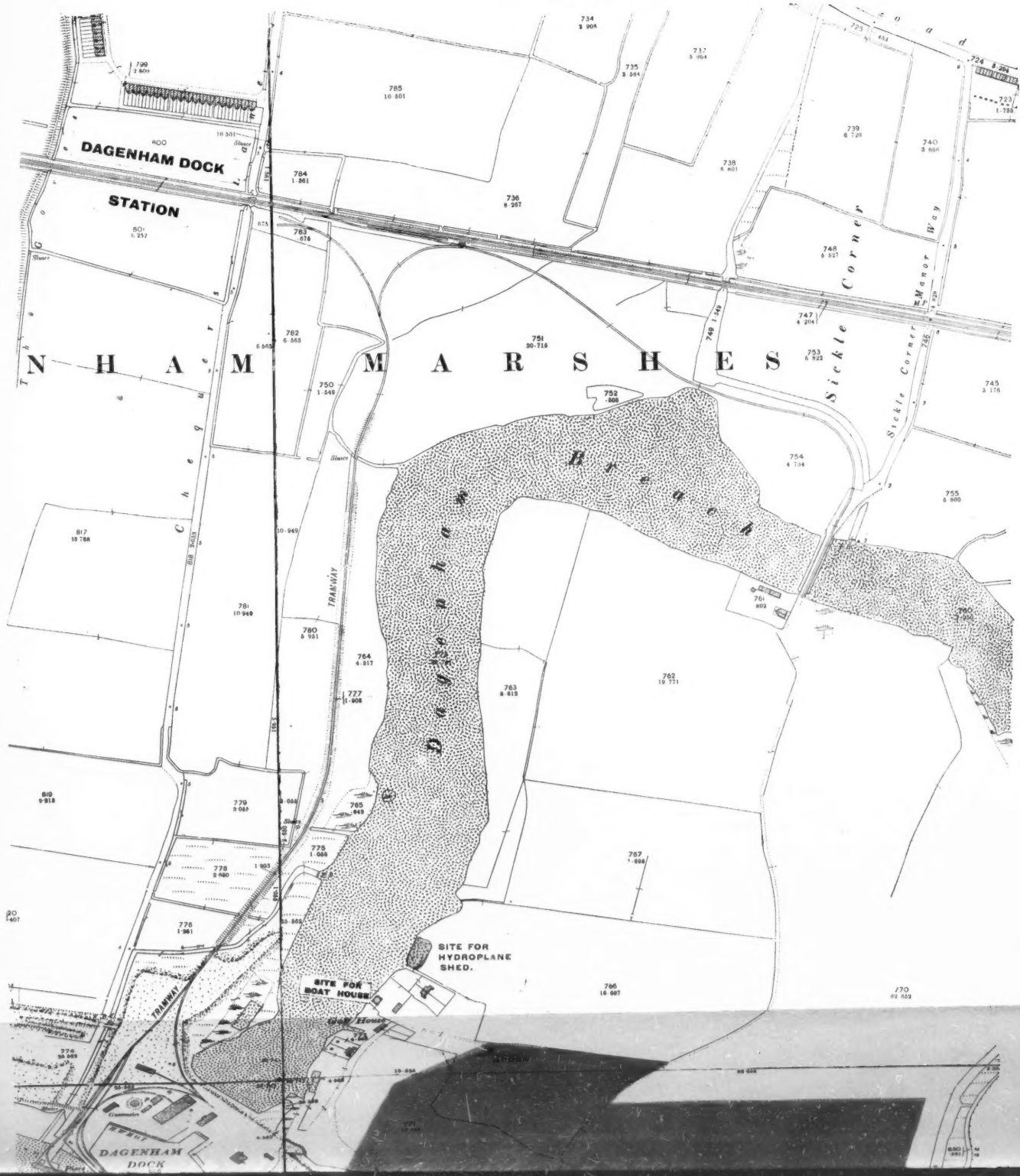
One other valuable characteristic of this ground is that the only buildings in the neighbourhood (within 300 or 400 yards) are the engineering works and houses of Messrs. Williams, where rough repairs to engines, etc., can be made, accumulators charged, and whence electric power can be laid on to the sheds. Already one member contemplates fitting up some electric tools in his shed. To these works runs a private branch railway, so that large goods sent by train can be landed at the grounds without transhipment. Goods can also be sent by sea and landed at the Dock.

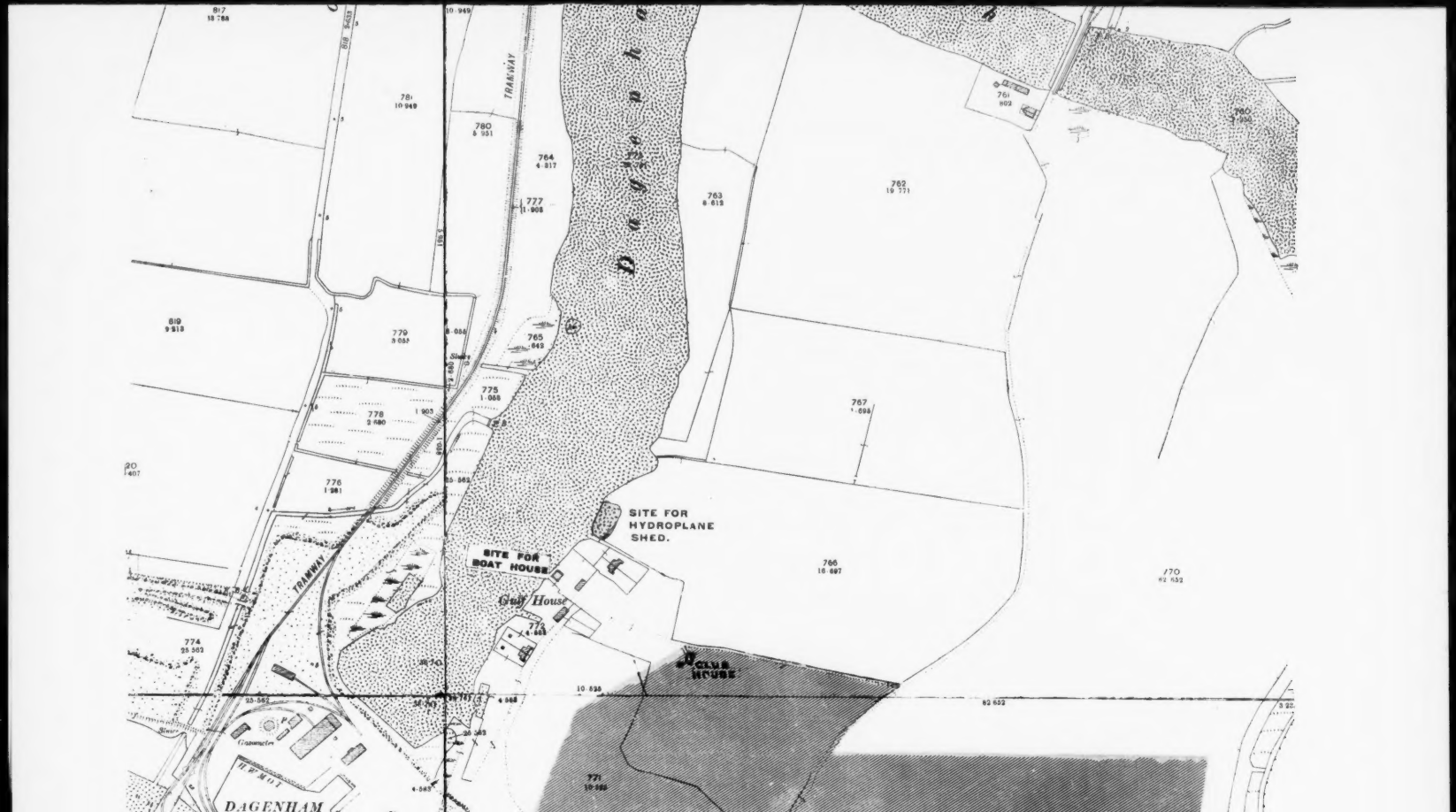
Considering that these grounds are only 14 miles by road from Charing Cross, an easy motor drive, that there are frequent trains from all parts of London, and that the station is only three-quarters of a mile from the ground, it is clear that, if not absolutely ideal, they possess many most valuable characteristics, such as are not to be got anywhere else.

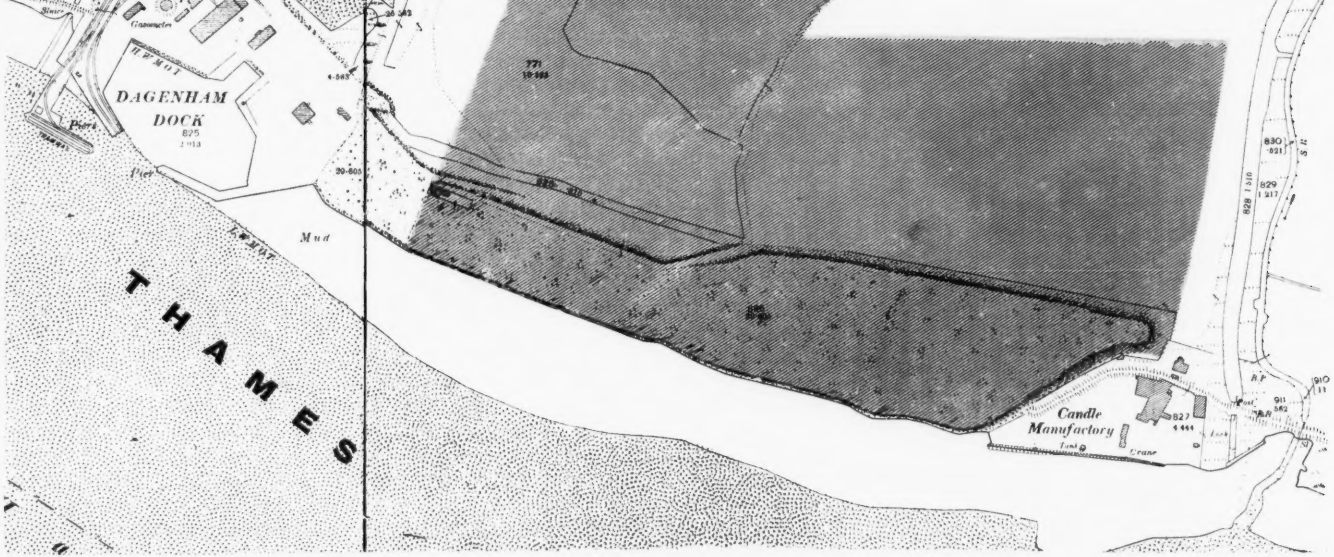
Donations to the Experimental Ground

	£	s.	d.
Alexander, P. Y.	100	0	0
Weiss, José	1	1	0
Balston, R. M.	3	3	0
Cody, Samuel F.	2	2	0
Ogilvie, Alexander	6	1	0
Wenham, Mrs.	3	3	0
Warren, Sir C.	4	4	0
Tinline, J. D. M.	3	0	0
Beresford, W. H.	1	1	0
Moreing, C. A.	1	1	0
Peache, Gilbert A.	2	2	0
Seeley, Sir C.	11	11	0
Gipps, Lt.-G., R.N.	1	1	0
Deane, Reginald	2	1	0
Eschereze, Hermann, ...	1	1	0
Edwards, Mrs.	2	2	0
Hubbard, T. O'B.	1	6	0
Antinori, J. C.	1	11	6
Gilbert, Walter Villa	2	2	0
Buchanan, John Y.	6	1	0
Maxim, Sir Hiram S.	5	5	0
Saul, G. P. D.	1	1	0
Frost, Ed. P.	6	1	0
Trollope, Col. F. C.	5	0	0
Lovelace, The Rt. Hon. the Earl of	11	1	0
Page, F. Handley	6	1	0
MacHaffie, J.	1	1	0
Thurston, Albert P.	0	10	6
Clarke, T. W.	1	11	6
Brocklehurst, Major R.	6	1	0
Keith, Alexander	2	2	0
Griffiths, W.	1	1	0
Edge, S. F.	1	1	0
Baden-Powell, Major	6	1	0
Fullerton, Col. J. D.	6	1	0
Childs, J. G.	1	1	0
Tolley, Frederick	1	1	0
Nesfield, Albert C.	1	1	0
Van de Weyer, Capt. B.	1	1	0
Reid, W.	1	1	0
Massey, Col. H. S., C.B.	1	1	0
Dines, W. H.	1	1	0
Tidswell, Mrs.	1	1	0
Capper, Col. J. E., C.B.	6	1	0
Kennedy, F. S.	2	1	0
Blackden, Lt.-Col. L. S.	1	1	0
Urban, Chas.	1	1	0
Holwell, R. D.	1	0	0
Norrie, H.	2	2	0
R. L. Foster	1	1	0
Carden, Sir J., Bart.	1	1	0
Buckton, W. W.	1	1	0
Lloyd, H. F.	1	1	0
New, A. G.	1	1	0
Schlesinger, Capt. C. E.	1	1	0
Buist, H. Massac	2	2	0
Davidson, G. L. O.	1	1	0
McClean, F. K.	1	1	0
Egerton, Lieut. W., R.N.	1	1	0
Total	£218	18	6

EXPERIMENTAL GROUND, DAGENHAM DOCK.




SITE FOR HYDROPLANE SHED.
SITE FOR BOAT HOUSE
Golf House
CLUB HOUSE
TRAMWAY
DAGENHAM


DAGENHAM
DOCK
825
1913
Mud
THAMES
Candle
Manufactory
827
4 444
771
10 588
830
831
829
1 917
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1 310
910
11
911
162

CORRESPONDENCE

Grove House,
Bodney Road,
Hackney Downs,
December 10, 1908.

SIR,—In answer to your invitation I take the opportunity of entering into the discussion of Mr. Lanchester's interesting and instructive paper on "A Comparison of the Wright and Voisin Flying Machines," although, since this paper is not to hand, I am not able to discuss it as fully as I should like.

Let us first consider the question of the propellers.

1.—A screw propeller derives its thrust by giving motion to the air, and since it is clear that it is more economical to give a large mass a small velocity rather than a small mass a high velocity it follows that a screw should be designed to engage as much air as possible. It is found with stationary two-bladed propellers suitable for driving aëroplanes in which the blades are of carefully and correctly shaped wood that

$$\text{horse power} = \frac{\text{thrust} \times \text{slip}}{33{,}000}$$

With such a propeller it is also found that the thrust does not very greatly fall off up to a speed of 70 per cent. of the slip speed. The Wright machine is undoubtedly much more efficient than the Voisin machine, and this appears to be in part due to the fact that the double propellers of the Wright machine engage between 6 and 7 times more air per horse power than the single propeller of the Voisin machine. Moreover, the propellers of the Wright machine are of wood and are perfectly smooth stream-line surfaces, while the propellers of the Voisin machine consist of metal paddles at the end of metal rods, and have wasteful humps on the back of the paddle or blade where the rod is welded to it.

2.—Placing two propellers axially behind one another and revolving in opposite directions, as Mr. Lanchester suggests, would have its advantages, but its great disadvantage would be in the fact—and this would outweigh all the advantages—that only half the quantity of air would be engaged. Hence one of the chief secrets of the superior efficiency of the Wright machine would be sacrificed.

3.—By placing the propellers behind the machine in the centre of maximum resistance it is found that some of the energy lost by the disturbance of the air caused by the passage of the aëroplane can be recovered by the propellers.

4.—The side by side disposition of the propellers of the Wright machine enables the maximum use to be made of this most important fact.

5.—The Wright machine also appears to be the more efficient type in that the framework of the aëroplane is covered in, thus making the aëroplanes smooth stream-line surfaces, whereas in the Voisin machine the framework of the aëroplanes is exposed on the back.

6.—Mr. Lanchester suggested in the course of his remarks that the behaviour of aëroplanes and propellers in air and in water is similar, subject to a correction for density.

7.—It must not be forgotten, however, that water wets a surface, air does not; water possesses viscosity and cohesion—the particles adhere together and resist separation—air has no measurable viscosity and the molecules are always doing their best to get as far away from one another as possible. The only loss that can occur in skin friction with a smooth stream-line body appears to be that due to exchange of momentum, such as would result if people jumped from a train going at one speed into another going at another speed. Sir Hiram Maxim found that a propeller of no pitch and with the blades carefully shaped required no appreciable torque, whereas a disc of smooth sheet tin of the same diameter and driven at the same speed gave an appreciable torque.

8.—An air propeller differs also from a marine propeller, in that the air is the equivalent of an elastic nut which hugs the surface of the blade on both sides. For these reasons one is compelled to agree with Mr. Wilbur Wright, Professor Langley, and Sir Hiram Maxim in the statement that the skin friction is a quantity so small that it may be neglected.

9.—The resistance of an aëroplane appears to be due, not so much to skin friction, as to eddies set up by the parts of the aëroplane which are not of stream-line formation, and to other parts of the machine in which the opening, or passage-way, is restricted so that the air has to be accelerated to pass through.

10.—Despite the superior efficiency of the Wright machine its efficiency could, apparently, be still further increased in various ways, as by improving the shapes of the frame and uprights, and by constructing a "cut wind" to the motor, operator, etc.

11.—The weight of the Farman machine is surprising (1540 lbs., if I understood Mr. Lanchester correctly). This is 400 lbs. more than was previously thought, and with the area given—535 sq. feet—gives the high lift of 2.9 lbs. per sq. foot. The highest lift which I have measured was 7 lbs. per sq. foot. This, however, was at nearly one hundred miles an hour and with a small angle.

12.—The use of vertical planes in connection with the rear aëroplanes in the Voisin machine appears to be a good feature in that it enables the machine to adjust itself to meet

side currents which would upset it. A slight *cross* current of air causes the lift on one side of an aëroplane to be more than on the other. In the case of Sir Hiram's large machine a cross current of only 4 miles an hour caused the machine to lift a ton more on one side of the track than on the other. A cross current therefore causes an aëroplane to be subjected to a considerable upsetting torque. This may be obviated by twisting the planes, as in the Wright machine, by forming all the planes with vertical planes so as to assure the machine drifting with any unexpected cross current, as in Santos Dumont's first machine, "The Bird of Prey," or with one vertical plane, as in Mr. Cody's machine, or by forming the rear planes only with vertical planes so that a cross current will tend to turn the machine round to meet it, as in the Voisin machine. This feature of the Voisin machine appears to be of great importance and to give this machine more automatic stability than that possessed by the Wright machine.

13.—Will Mr. Lanchester be good enough to give further information with regard to the diagram of the lines of motion of the air about two superposed planes which he threw on to the screen? This diagram, it seemed to me, appeared to show *the air rising up to meet the aëroplane* as if the plane or curve had some cohesive or other attraction for it. This is contrary to what I should have expected from experiments which I have seen.

14.—With regard to the minimum horse power required for flight, Mr. Wilbur Wright recently said: "Two years ago, with a motor of only 14-h.p., I drove an aëroplane weighing $11\frac{3}{4}$ cwt., and carried one passenger with me. I deem it impossible ever to do better."

In conclusion, I would warmly thank Mr. Lanchester for his interesting paper.

Yours faithfully,

ALBERT P. THURSTON.

Answer to Communication of Mr. A. P. Thurston

On reading through the communication of Mr. Thurston I first observed that it embodied fallacies (to which further reference is made) apparently taken direct from Sir Hiram Maxim's book on flight. I next observed that Mr. Thurston is the kind friend to whom Sir Hiram in his preface acknowledges his indebtedness for reading his proofs; consequently I take Thurston to be Maxim in disguise, or the mechanical equivalent thereof.

I have numbered the paragraphs in Mr. Thurston's communication, and in the following reply these numbers are used to facilitate references.

1.—The first portion of this paragraph is a statement of the Newtonian principle applied to the screw propeller by Rankine and Froude. I have given a summary of this in my "Aërodynamics," 198 *et seq.* The latter part gives Maxim's result that with certain propellers used by him under stationary running conditions the influence of skin-friction is inappreciable. I do not dispute this fact, but I say definitely that it in no wise proves that skin-friction as a factor in flight resistance or in propeller design is negligible, the conditions of a propeller under running conditions is very different. Certain analogous phenomena are known in the behaviour of an inclined aëroplane, for a plane making a considerable angle to its direction of motion, skin-friction is an unimportant part of the total resistance.

I do not understand how Mr. Thurston makes out that the Wright propellers engage 6 or 7 times as much air as the Voisin; I fear his arithmetic is at fault, the actual figure is nearer $2\frac{1}{2}$ times. Evidently Mr. Thurston has not seen the Wright propellers except on paper, for they are not "perfectly smooth," and are but a poor apology for stream-line form. As to the disparaging remarks made on the design of the Voisin propeller, also based on Maxim's book, p. 106, I could show Mr. Thurston experiments that indicate that the resistance due to a rib on the rarefaction face of an aëroplane is far less than he and Sir Hiram seem to think. The drawing (p. 106) in Sir Hiram's book is plausible, but it does not represent the facts. The whole of this paragraph seems to imply that I have not allowed sufficient credit to the Wright propeller on the score of efficiency, but all the facts mentioned by Mr. Thurston that are pertinent have received due consideration.

2.—It is quite true that if two propellers are placed tandem, unless (as they should be) they are made of larger diameter, there is some loss of efficiency on the score named. There are, however, certain advantages that to some extent compensate for this loss, as is found to be the case in the Whitehead Torpedo, in which this arrangement is adopted.

3.—Of what is this paragraph *apropos?* The whole question here raised is thoroughly treated in pages 199, 200 and 201 of my "Aërodynamics," but what bearing Mr. Thurston's remarks have on the subject of my present paper I do not know. The Voisin disposition appears to me to be as good as, or better than, the Wright in this respect, except in the Goupy type, and this has been already pointed out in my paper.

5.—The framework of the Voisin machine is covered in also. This is pointed out in my paper and was illustrated on the black-board in the course of the reading.

6.—This is true. I believe that the be-

haviour of a propeller and the laws governing its efficiency are the same in air and in water, subject to the substitution of the appropriate constants in the one case or the other.

7.—Mr. Thurston appears to be hopelessly at sea as to the physics of the subject. He states that air has no measurable viscosity. This is not a fact; the viscosity of air has been measured and is well known, as reference to any reliable work on physics will convince Mr. Thurston. As it happens, the criterion in fluid dynamics is what is termed the *kinematic viscosity* of the fluid, and this for air is *fourteen times as great* as for water. There is no need to deal with molecules in the discussion.

8.—In this and the preceding paragraph we have a quantity of fallacy, for which I fear Sir Hiram Maxim is mainly responsible. The statement that water *wets* a surface, whereas air does not (p. 44 of Maxim's book), is either a merry jest on the part of Sir Hiram, or else it pleases him to differ with every physicist of repute in the country. It is a curious fact that although the logical consequence of the doctrine of the negligibility of skin friction is a propeller of very fine pitch and very large diameter, this is not the form that Sir Hiram Maxim actually employs.

9.—The resistances of the kind mentioned by Mr. Thurston are mentioned and allowed for in my tabular estimate of the resistances of the two machines.

10.—*Ça va sans dire.*

11.—I ascertained the weight of the Farman machine from the constructors (MM. Voisin frères), and I believe it is correctly stated; the pressure per square foot, 2.9 lbs. per sq. ft., is, I believe, correct; it agrees with my theoretical tables of least resistance based on a co-efficient of skin-friction of 1 per cent. (Comp. "Aërodynamics," p. 271, $n=5$ velocity 70 ft. /sec. load for least resistance = 2.86 lbs. per sq. ft.).

12.—The use of vertical planes for the purpose under discussion is older than any of the instances given. I used it in model free flight experiments in 1894 ("Aërodonetics," Chap. I.), it is described in my patent 3608 of 1897, and I have employed the same method continuously for model work ever since.

13.—Again the cloven hoof! Sir Hiram publicly jeers at this diagram or rather a distorted imitation (p. 104 of his book). The answer to the question will be found in Chap. IV. of my "Aërodynamics." The question might well be posed in the opposite sense—what mysterious force is there to prevent the air in advance of the aërofoil or aëroplane from acquiring a velocity from the region of greater pressure beneath towards the region of lesser pressure above?

14.—Probably Wilbur Wright's velocity of flight was far lower when he did the performance to which reference is made. For a small low velocity model I have reduced the h.p. required to 1-h.p. for 500 lbs. sustained, the power being supplied by gravity. This is equivalent to about 330 or 350 lbs. sustained per h.p. by means of a screw propeller of 66 per cent. or 70 per cent. efficiency.

F. W. LANCHESTER.

Errata

In Mr. H. C. Vogt's article "On the Action of Aërial Propellers and Aëroplanes," in the January (1909) number of the "Aëronautical Journal," a considerable number of printer's errors occurred, for which we beg to apologise, and hereunder correct:—

Page.	Column.	Line	
23	2	50	... "(Swinging t round)"
24	1	20	... "68 mm., or 2.7 inches"
24	1	22	... "31 mm. at the inner hole."
24	2	12	... "$f\ m\ A\ V^2 \sin\alpha_1$,"
24	2	53	... *Substitute for* "by means of the suction centre," "towards the diminished pressure."
24	2	55	... *Delete* "upon."
25	1	5	... *Delete* "often a small part."
25	2	49	... "different angles of keel."
25	2	55	... "$f\ m\ A\ V^2 \sin^2\alpha$"
25	2	56	... "close-hauled sailing"
26	1	19	... "coefficient f"
26	1	20-28	... *Substitute* "The formula published nearly 20 years ago in *Engineering*, *Steamship* and other journals, resulting from these experiments was: $T\alpha = f\ m\ A\ V^2 \sin^2 \alpha + V$, where V represents the rarefaction. $T\alpha$ = the normal thrust on the sail. A practical formula for $T\alpha$ is: $T\alpha = f \sin\alpha\ T_1$, where f for small values of α (5-8 degrees) is about 2.8; for $\alpha = 30°$, $f = 2.2$, *i.e.*,"
26	1	58	... "The formula $T\alpha = f\ m\ A\ V^2 \sin^2\alpha$ V was"
26	2	1 & 2	... "(Until $\alpha = 10°$, f is about 0.9 and between 30°-90° f is about $\frac{1}{2}$)."
27	1	5	... "$150 \times 2.3 + 23 \times 50 +$"

The Aëro and Motor Boat Exhibition

By COL. J. D. FULLERTON, R.E.

This exhibition, organised by the Society of Motor Manufacturers and Traders, Ltd., was held at Olympia from the 19th to the 27th March, 1909.

The aëronautical portion attracted considerable attention, and the Society is to be congratulated on the result of its efforts to interest the public in aëronautical matters.

It is not proposed in these notes to give an account of all the exhibits, but an attempt will be made to describe those in which the members of the Aëronautical Society of Great Britain are more especially interested. Motors are only briefly touched on, as they are discussed in Mr. McKinney's paper.

[N.B.—The numbers given are the numbers of the Stalls as shown in the official catalogue.]

No. 21.—"AERONAUTICS."

The Aëronautical Society of Great Britain.

The following is a complete list of the very interesting prints, etc., shown by the Society:

1. Count Lennox's "Eagle" (Dirigible) [Old Print].
2. Portrait of Robert Cocking and Ascent of the Royal Nassau Balloon with Cocking's Parachute [Old Prints].
3. Monck Mason's Aërial Machine [Old Print].
4. Portrait of Tiberius Cavallo, Esq. [Old Print].
5. La Minerve (Robertson) [Old Print].
6. Portraits of the Nassau Party, 1836 [Old Print].
7. Map of the Society's Experimental Ground at Dagenham.
8. Tableau d'Aviation.
9. Portrait of James Sadler [Old Print].
10. Portrait of Dr. Sheldon [Old Print].
11. "Fowls of a feather flock together," portraits of Lunardi, Tytler, etc. [Old Print].

And a set of the Society's "Annual Reports" and "Aëronautical Journal."

No. 52.—MR. F. R. SIMMS

(Member of the Aëronautical Society of Great Britain).

This machine is a Voisin Bi-plane, cellular type. The total weight carried, including the driver, motor, petrol, water, etc., is 1,300 lbs.; normal speed in still air, on a level course, 45 miles per hour. The centre of gravity is at the centre of the propeller, and the total resistance at the normal speed is estimated to be 220 lbs., with a gliding angle of 9°. The two sustainers have ash framework and are covered with Continental fabric. Dimensions: Each 33 × 6½ ft., giving a total sustaining area of 537 sq. ft.; angle of inclination at normal speed = 2°; weight per sq. ft. of surface = 2.42 lbs. The estimated resistance of the sustainers is 100 lbs., which makes the ratio of drift to lift $\frac{1}{1.5}$. In section the sustainers are arched $\frac{1}{20}$; maximum rise being at a point one-third of the width of the surfaces from the front. The surfaces are not warped.

The driver's seat, motor, etc., are fixed on the lower sustainer, the body being represented by a four-wheeled chassis fitted with springs to absorb the shock of landing. The motor is of the Simms type, six cylinders, set at 120°, bore 110 mm., stroke 110 mm.; weight without fly-wheel, 220 lbs.; total weight, including radiator, etc., 270 lbs.; carburation by simple single jet carburettor with throttle and air valves; Simms' magneto ignition. As regards constructional details, the cylinders are of cast-iron; forced feed lubrication by gear oil pump to main bearings, through hollow crank shaft, up hollow connecting rods to pistons. Automechanical inlet valves over exhaust valves.

The power developed is 50-Brake H.P. at 1,000 revolutions; the motor can be accelerated to 1,600 revolutions.

The fuel used is petrol (18,000 B.T.U.), and the expenditure is .2 gallons per H.P. hour. Capacity of the tank is 10 gallons.

There is one Voisin type propeller, 7.5 ft. in diameter and 5 ft. pitch, gear driven, and revolving at half the speed of the engine. The stationary thrust = 360 lbs.; the thrust while in motion = 220—efficiency = 75 per cent.

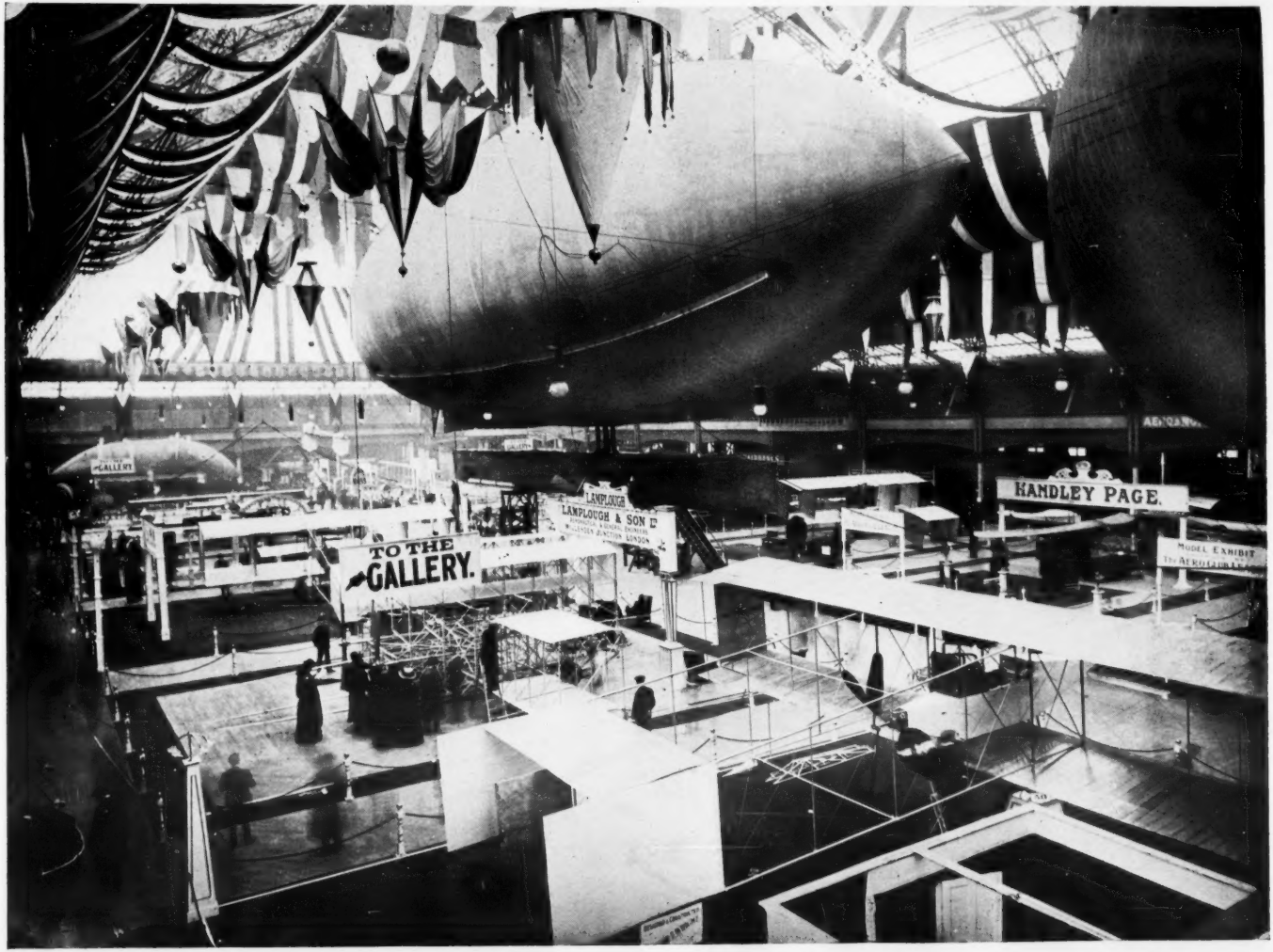
Steering in a horizontal plane is done by a rudder fixed in the rear box surfaces, actuated by wires from the steering wheel. Steering in the vertical plane is carried out by altering the angle of inclination of the front box elevators.

No special starting gear is used; the machine is simply run along the ground for a distance of about 150 yards and rises when a velocity of about 30 miles an hour is reached. As regards alighting, any shock is taken by the spring-mounted wheels as above explained.

No. 50.—MR. HOWARD WRIGHT

(Member of the Aëronautical Society of Great Britain).

This machine is of the Voisin Bi-plane type; total weight with two passengers = 1,100 lbs. The normal speed on a level course is 35 miles per hour; estimated gliding angle 7° to 9°.


TO THE
GALLERY.
LANPLOUGH & SON
HANDLEY PAGE.
MODEL EXHIBIT

The sustainers are each 40 ft. × 6½ ft., and have a total area of 520 sq. ft., but if the front elevator and rear tail are counted as sustainers, the total area = 620 sq. ft. In section the sustainers are somewhat of the best Phillips type, but are said to give better results; distance between the sustainers = 6½ ft. The weight carried per sq. ft. of main sustainers = 2.1 lbs. There are two vertical planes at the ends to assist turning. As regards construction, the uprights between the two planes are of steel, and of a special pear-shaped section (of least resistance); while the covering material is linen specially treated so as to give a very smooth surface.

The body is of canoe shape, the framework being of steel tubing, and has accommodation for two passengers. There are two wheels, one under the lower main plane, fitted with a spring fork, the other under the rear box tail. To assist landing there are two small wheels fixed at the front ends of the lower sustainer.

The motor is a standard 26-H.P. Metallurgique; bore = 105 mm.; stroke = 120 mm.; 4 cylinders. Weight of motor only = 300 lbs.; radiator = 37 lbs.; forced oil lubrication; pressure on bearings 60 lbs. to sq. in. At 1,500 revolutions 50-B.H.P. can be developed.

The amount of fuel (petrol) carried is 15 gals.

The propellers are of special design, two two-bladed units working in reverse directions on one shaft. The thrust at 36 miles per hour = 360 lbs. Revolutions one-third those of the engine, viz., 500; efficiency = 73 per cent. Diameter = 8 ft. For steering in a vertical plane there is the usual type of double rudder in front, while steering in the horizontal plane is managed by a rudder in the box tail in rear.

There are no special arrangements for starting; the machine is run along the ground under its own power, rising with a velocity of 25 miles per hour when a distance of 30 yards has been passed over.

The alighting is done in the usual way, any shock being taken up by the spring fork of the front wheel.

Great care has been taken in this machine to reduce the resistance to forward motion as much as possible, all exposed framework, tanks, etc., being made of a special pear-shaped section, shown by experiment to give very small resistance at high velocities.

The machine is intended to be essentially one for learners, and no attempt is made to attain high velocities.

No. 31.—MR. J. T. C. MOORE-BRABAZON

(Member of the Aëronautical Society of Great Britain)

This is a Voisin Bi-plane Machine, almost exactly like the one described above (Mr. Simms'), the only practical difference being that the distance between the two sustaining surfaces is 6½ ft. instead of 5 ft.

The motor is an 8-cylinder E.N.V. engine, giving 80-H.P.; its weight = 280 lbs.

Mr. Moore-Brabazon has made a number of successful flights in this machine, viz., three of 1 to 2 kilm. at Issy, and about a dozen at Chalons of from 1 to 5 kilm., at heights up to about 50 feet.

No. 30.—MR. HANDLEY PAGE

Mr. Jose Weiss

(Member of the Aëronautical Society of Great Britain)

MR. JOSE WEISS' MACHINE

This machine is a monoplane of the bird type. The total weight, including passenger and fuel, for 1 hour, is about 500 lbs. The estimated total resistance to forward motion is about 30 lbs., which gives a ratio of drift to lift of $\frac{1}{17}$. The estimated normal speed is 40 miles per hour. The gliding ang'e in still air (without the chassis) is said to be about $\frac{1}{15}$.

The area of the sustainers is 150 sq. ft., and the weight carried per sq. ft. = 3.3 lbs. at the normal speed. The cross section is of the birds' wing type, the central parts of the wings being deeply arched in front, with slightly flexible rear surfaces, while at the tips the front arching is very small, the back part being a flexible reversed curve, to give automatic stability. As regards construction, bamboo and stout linen are used at present, but a better class of material will be used in future machines. The body is shaped like the body of a bird, accommodation being provided for one passenger, who sits on a bicycle saddle.

A steel tubing frame fixed in the centre of the body carries the motor and propellers.

The chassis has four wheels so connected with the wings that if, when on starting, a side wind springs up, the whole machine is, by means of the wing pressure acting on the wings, brought automatically into the face of the wind.

The motor is a 12-H.P. 3-cylinder Anzani; bore = 76 mm.; stroke = 86 mm. Number of revolutions = 2,000 per minute. Weight of the motor complete with carburettor coil, etc. = 100 lbs. No radiator is used, the motor being kept cool by the air. One hour's supply of fuel (petrol) is carried. There are two propellers, placed just in rear of about the centre of each wing. The propellers have two blades; diameter = 6′ 4″; pitch 8 ft.; ball bearings; revolutions 700 per minute. The thrust line is very high up, being nearly on a level with the line tangential to a wing section taken half-way between the shoulder and tip of the wing. The thrust, standing still, is said to be about 60 lbs.

Steering in a vertical plane can be done in three ways—slight movement of the rider's weight backward or forward, thus increasing or decreasing the angle of inclination of the machine; accelerating the motor, and thus ob-

taining a higher thrust; and finally by working from a pedal two small flaps in rear of each wing.

Steering in a horizontal plane is also done by working the flaps above alluded to, but can, if required, be carried out by shifting the rider's weight from side to side, or by using a special mechanism for working the tips of the wings up and down.

It is intended to start the machine by running it along the ground in the manner already described for other machines.

No. 51.—MESSRS. LAMPLOUGH & SONS
The Lamplough Compound Lifter-Plane and Glider

This machine is of an entirely novel type, the main idea being to at first use parts of the sustaining surfaces as flapping wings to raise the machine in the air, and then, when the required level is attained, to stop the flapping and drive the machine with propellers as an ordinary aëroplane.

The machine was only partly finished, but enough was exhibited to show its general principles.

It consists of a body, carrying the passenger, motor, propellers, and the gear for working the lifting planes; two sustainers of the double deck type arranged one on each side of the centre of the body, and two upper lifting surfaces placed about 18 ft. above the lowest level of the body.

The body and lower sustainers are of a more or less familiar type, but the lifting surfaces are arranged in a rather peculiar way, their longest sides being parallel to the axis of the body. By a special form of gearing they are made to describe a figure-of-eight curve, on the principles laid down by Pettigrew, and the inventor attaches great importance to this part of the machine. The total weight of the machine when completed will be about 950 lbs., and the estimated power of the motor is 20-30-H.P.

No. 35.—CAPT. W. WINDHAM

This is, practically speaking, a Voisin type machine, the builders, however, being Messrs. Pischoff and Koechlin. The total weight, with driver, is about 800 lbs., while the sustaining surface is about 600 sq. ft. The motor is a two-cylinder "Dutheil-Chambers" engine, bore = 125 mm.; stroke = 120 mm.; giving 20-H.P. There are two propellers, fixed just in rear of the main planes. Steering in the vertical plane is done by moving the front elevating rudders, while steering in the horizontal plane is effected by moving a rudder fixed in the tail. A noticeable point is that the front and rear directing surfaces are much further from the main planes than is the case in the Voisin type machines. Transverse stability is ensured by "ailerons" or small surfaces fixed between the two main planes towards their outer extremities. Starting is done in the usual way, by running along a smooth piece of ground until the machine lifts in the air.

No. 34.—MESSRS. SHORT BROTHERS

This machine is of the Wright type. Its weight alone = 700 lbs., and, allowing for two passengers, the weight in order of march is about 1,100 lbs. The normal velocity is from 35 to 40 miles per hour.

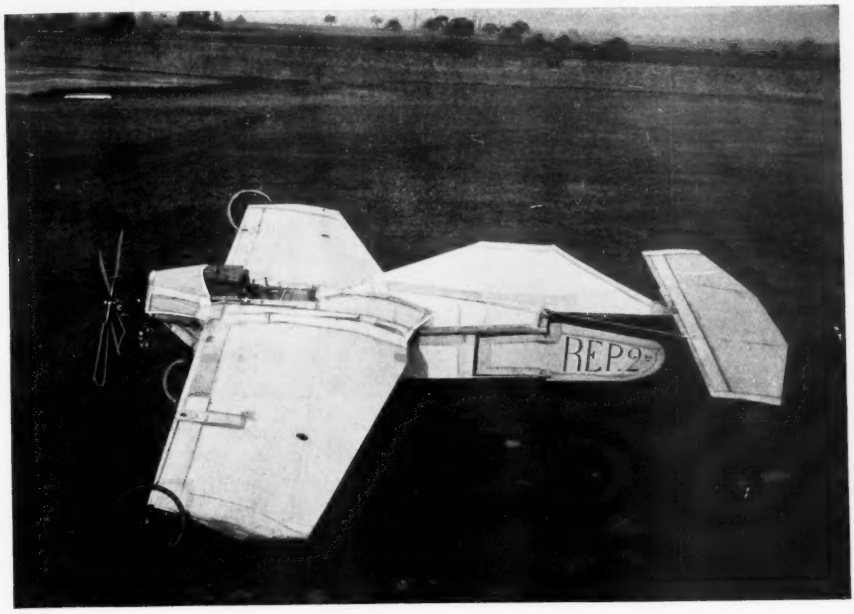
The main sustainers are 40 ft. × 6½ ft., and the total sustaining area is 530 sq. ft., giving a lift = 2 lbs. per sq. ft., approximately. In section the sustainers are curved to a special curve designed by Messrs. Short; the angle of inclination of the chord of the curve at normal speed is about 7½°. The motor has not yet been decided upon, but one developing 35 to 40 H.P. will be used. There are two two-bladed propellers 9 ft. in diameter fixed in rear of the main surfaces, their design being one of Messrs. Short's own. Steering in the vertical plane is done by the usual type of front elevator, while steering in the horizontal plane is managed by two small rudders fixed in rear of the outer extremities of the main sustainers. These rudders really work in a sort of box formed by extending the outer ends of the main planes about 5 ft. to the rear. The starting arrangements are not quite settled, but it is intended to use a starting rail of some kind.

The machine was not finished, the Continental fabric which it is intended to use for covering not having been fixed. The framework, however, showed out very well, and an excellent idea of the constructional details was obtained.

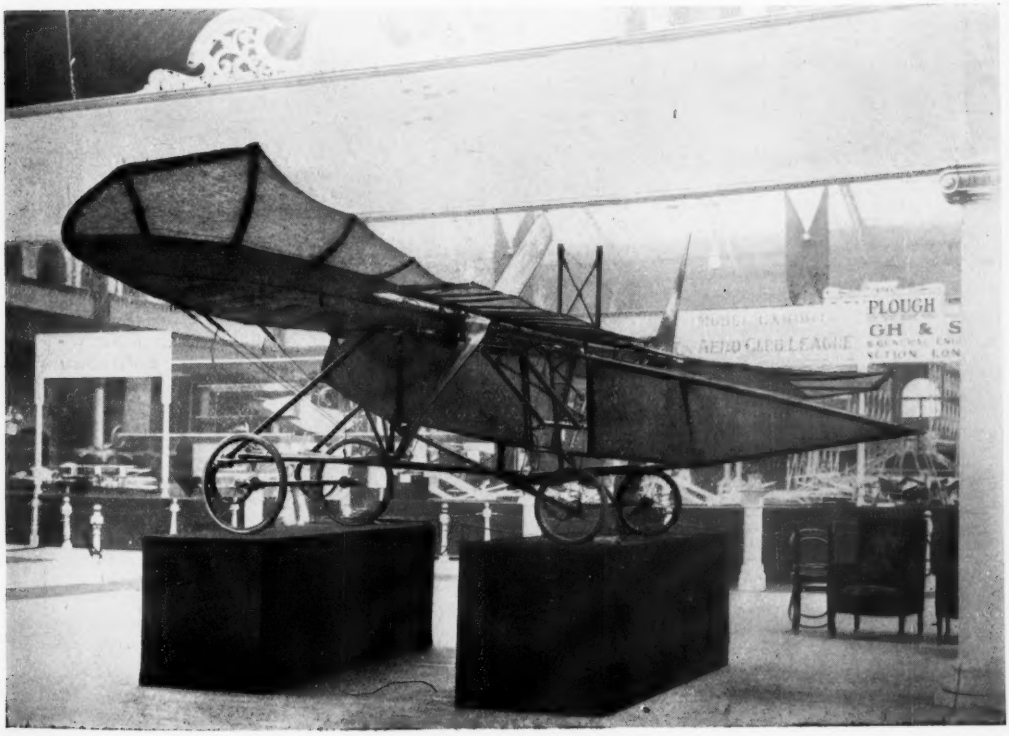
No. 54.—MASS CARS
Delagrange Aëroplane (Bi-plane Type)

This machine is also of the Voisin type. The sustainers are each 34 ft. by 7 ft., the vertical distance between them being, however, only 5½ ft. The front elevator planes are each 6½ by 2¾ ft., while the box tail in which the rudder for steering in the horizontal plane is fitted is about 8 ft. × 7 ft. The chassis has pivotting wheels connected by means of shock-absorbing springs, and there are two small pivotting wheels under the tail. As regards transverse balance, this is secured by four vertical surfaces in the main sustainers, and two similar surfaces in the box tail.

The motor is a 50-H.P. Antoinette; the single propeller works at 1,100 revolutions per minute.



M. Esnault-Pelterie's Monoplane



The Weiss Monoplane

Starting is arranged for by running along the ground as in the other Voisin type machines.

No. 33.—THE MIESSE PETROL CAR SYNDICATE
M. Adhémar de la Hault

This machine is of the beating wings type, and is quite unlike any of the other exhibits. It consists of three main parts, viz., the chassis, on which the motor is fixed, a vertical framework, high up in which the driver sits, and the two wings (with the necessary gearing) for sustention and propulsion.

The total weight is said to be about 400 lbs. with driver.

The sustainers, viz., the wings, are formed something like a bird's wing with the outer part cut off; area sustaining surface = 72 sq. ft. The main idea of the invention is to flap the wings in a figure-of-eight curve, as described by Pettigrew. The inventor's description of the gearing, etc., required to do this is as follows:—

"The object of the invention is to utilise a rotative movement by transforming it into a bend of an 8 by the intervention of a universal joint on to the wing. The wing is carried by an arm, which projects horizontally from a ball joint, and works freely in a phosphor bronze cup adapted to a small lever revolving on a fixed pin, making the centre pin a fixture, which forms an axle for the socket. When the drive is given to the gears fixed to the outside sleeve, the latter drags the fork, which makes the axle or pivot turn, carrying the socket, and this movement immediately works the wings. These wings are animated by a flapping provoked by the movement of the small lever, which drags the cup in a swinging movement and gives a complete revolution of the fork holding the wing, and immediately after a movement from right to left or *vice versâ*, the wings return to their original position, after having made a complete figure of 8."

The vertical framework and chassis are of steel tubing, the latter having four wheels, for starting and alighting.

The motor is 100-H.P. Miesse, 8 cylinders, bore = 130 mm., stroke = 140 mm. The crank shaft which communicates direct with the wing gear is fixed vertically, the cylinders being arranged horizontally and opposite each other.

Propulsion is carried out by the wing movements, the wings being, as with a bird, both sustainers and propellers. The steering in any direction (vertical and horizontal) is managed by altering the wing inclinations.

When starting the wings are apparently made to beat very nearly vertically downwards, the machine being, consequently, lifted almost vertically. Alighting is managed upon the same principle.

No. 29.—THE BREGUET-RICHET AERÓPLANE

This machine is of the Bi-plane Voisin type, but it has some important modifications. Its weight without passengers is about 1,320 lbs., and there is accommodation for two passengers. The estimated normal velocity is 43.5 miles per hour, while the maximum speed of which the machine is capable is considered to be 55.9 miles per hour.

The area of the sustainers = 516.7 sq. ft.; cross section of the Phillips type, with the front edges bound with sheet aluminium. The ribs are of pressed aluminium. There is an ingenious arrangement for folding the outer parts of the sustainers backwards, so that when being transported by rail, etc., the space occupied by the machine, completely packed, is reduced to an area $7\frac{1}{2}$ ft. wide by 20 ft. in depth.

The body is of steel tubing, and a hydro-pneumatic system of suspension will eventually be fitted. There are three wheels, with patent spring suspension, the main ones being directly under the motor frame, the other under the box tail.

The motor is an 80-H.P. Gobron-Brillié: 8 cylinders (16 pistons), X type; bore = 90 mm.; stroke = 160 mm.; weight complete with $3\frac{1}{2}$ gallons of water = 330 lbs. Revolutions = 1,600; the amount of fuel, etc., carried is 176 lbs.

There is one two-bladed propeller; diameter = 8′ 4″; weight of propeller = 13.2 lbs.

Steering in the vertical plane is done by movements of the front planes only; for steering in horizontal plane two rudders fixed in the box tail are used, there being in connection with these latter a system of tilting the front planes.

Starting is arranged by running along the ground until the machine rises in the air, as usually done by the Voisin type machines.

No. 53.—M. R. ESNAULT-PELTERIE

This machine is of the bird type; total weight in working order with driver = 924 lbs.; normal speed = 37.2 miles per hour.

The sustainers have an area of 155 sq. ft., and, consequently, lift = 5.93 lbs. per sq. ft. Their section is of the bird's wing type, and in plan they represent a bird's wing with the tips cut off. The main framework of the sustainers consists of neutralised wood ribs joined by two wood and aluminium rods, the whole system being very flexible. Two shrouds, each of which carries one fourth of the weight,

control the movements of the wings. There is a small wheel at the tip of each wing.

The body is bird-shaped, and is constructed of steel tubing. It has two wheels, one large one carrying most of the weight, just below the motor, and another smaller one just under the tail. The front wheel is fitted with an oleo-pneumatic brake for safety purposes. The motor is a 35-H.P. R.E.P.; 7 cylinders, placed fan-wise in two parallel lines; air cooled, a special cooling fan being used for speeds under 28 miles per hour. An oil tank of 1½ gallons capacity, and a spirit tank of 10 gallons are carried; these are sufficient for two hours' working.

The propeller has four blades, diameter = 6½ ft. and is fixed in front directly on the crank-shaft of the motor. The revolutions are the same as those of the motor, viz., 400 to 1,500 per minute; at these speeds normal work is done.

Steering in a vertical plane is done by a tail, which can be moved up or down, so as to increase or decrease the machine's elevation; this tail, when in the normal position, contributes to the longitudinal stability of the apparatus. Steering in the horizontal plane is done by moving a vertical rudder placed just between the rear end of the body and the tail above mentioned.

When starting the machine rests on the two main wheels and *one* of the wing wheels; as soon as speed is got up it takes up its normal position, and rises in the air when the velocity is about 37.2 miles per hour.

This machine won the third prize for a 200 m. flight on November 21st, 1908, against a wind having a speed of from 19½ to 26½ ft. per sec.

No. 47.—MR. J. D. TINLINE
(Member of the Aëronautical Society of Great Britain)

This machine, though only a large model, is best described here. It is of the Voisin Bi-plane type, and weighs, complete with motor, etc., just under 68 lbs.

The sustainers are 8 ft. × 2¾ ft., and have, with the box tail, a total supporting area of 76 sq. ft. In section they are of the Turnbull type (see the "Aëronautical Journal," Vol. XII., p. 63).

The struts are shaped so as to offer a very small resistance to the wind, and are thickest in the centre, where the thrust is a maximum. Like all the rest of the machine, they are designed for easy removal, so that if one is broken or damaged its replacement by a new one is an easy matter.

The covering of the sustainers is balloon fabric, laced on to the framework of steel tubing. The back edges of the planes are flexible, but the planes themselves are not warped. The lower sustainer has a small wheel at each end.

The box tail planes are 4 ft. × 2½ ft., the distance between them being 2¼ ft.; the ends are covered in, and a small rudder 2 ft. square is fixed in the middle of the box. The front edge of the box tail is 3¼ ft. from the rear edge of the sustainers.

The body is of wood and in the shape of a box girder, the front planes being fixed to it by steel clips. It has one large wheel fixed at the front end, and there are two under the box tail.

The motor is of the horizontal type, giving 4½ B.H.P. at 2,000 revolutions. Two opposed cylinders; weight stripped, slightly over 20 lbs. The petrol tank fixed just over the motor by wires, holds one pint.

The propeller is driven direct from the crank-shaft, and has two metal blades constructed on the Maxim principle (like the sticks of a lady's fan).

As regards steering in the vertical plane "a pendulum 14 inches long with a 4-lb. weight at the end" is used. "This is connected to the horizontal steering planes and also serves to warp the back edges of the two steering planes fitted to the front box, the planes being warped in opposite directions."

With the exception of the engine crank case no aluminium is used in the machine.

No. 56.—MESSRS. SPENCER & SONS
(Member of the Aëronautical Society of Great Britain)

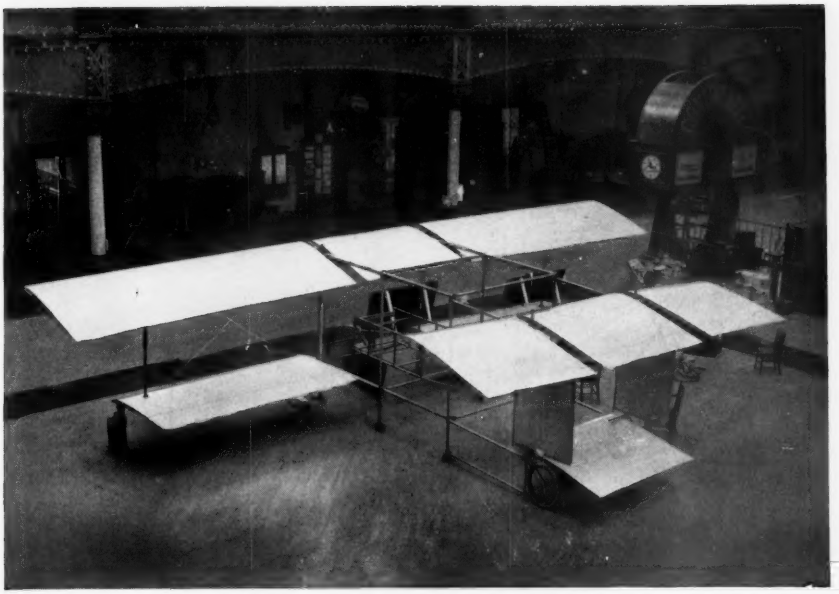
This exhibit consisted of a number of cars, hoops, valves, grapnels, etc., for passenger balloons; model of an aëroplane; some propellers, including one exactly like those used by the Wright Brothers; and an airship with elongated gas vessel, petrol motor, propeller, and rudder complete, etc. There were also a number of animal-shaped balloons for advertising purposes, and india-rubber balloons of various sizes for scientific and recreative purposes.

No. 55.—MR. F. S. CODY
(Member of the Aëronautical Society of Great Britain)

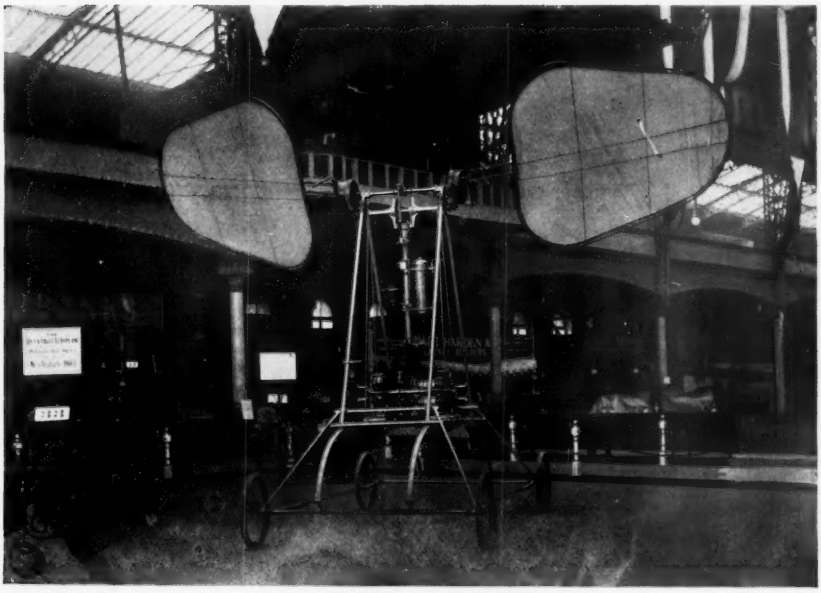
This exhibit consisted of some of Mr. Cody's man-lifting kites, with a complete carriage for reeling in and out. There was also an extremely interesting collection of photographs, showing Mr. Cody's flying machine in flight, the kites in action, and a number of photographs taken from the kites.

MODELS

On the stalls devoted to models there were some 70 odd exhibits. The numbers given below refer to the numbers in the catalogue.



The Breguet-Richet Bi-Plane



M. De la Hault's Ornithoptere

Nos. 4, 5, 6, 7.—MR. T. W. K. CLARKE, M.Aër.Soc.

This exhibit consisted of a beautifully-made model of the Wright Bros.' flying machine, with pylon, starting rail, etc., complete, on a scale of $\frac{1}{10}$; a similar model of the Voisin machine; the steering elevator of a full-sized machine now being made by him; and some very ingeniously constructed hollow wood spars, suitable for the framework of aëroplanes.

Nos. 8, 9, 10, 11.—MR. W. COCHRANE

A working model of his "oblique disc gear for transforming rotary into oscillating motion," as applied to wings. The gear can be adjusted by a lever so designed that the amplitude of the oscillations can be varied. On the down stroke of the wing the feathers are so arranged that they shall be rigid in the plane of the machine and slightly flexible at the extreme tips, while on the up stroke they will be at an oblique angle to the machine, thus giving a propelling force.

A design for a man-carrying machine on the above principles was shown. Speaking generally, the machine is of the bird type, sustention being chiefly carried out by a double-deck sustainer of the Wright type. Propulsion is intended to be effected by four small wings on each side of the machine. The total proposed weight = 380 lbs. with driver; thrust of the wings on the down stroke = 82 lbs.; on the up stroke = 132 lbs. Area of fixed surfaces = 270 sq. ft.; area of oscillating wings = $22\frac{1}{2}$ sq. ft.

The speed with a 15-H.P. motor would probably be about 36 miles an hour.

Mr. Cochrane also showed specimens of his corrugated aluminium material for covering aëroplanes.

No. 16.—MR. M. CREMONA

This model was principally noticeable for its method of propulsion, which was of the fish-tail type. Fans working in covered passages forced air on the sides of a kind of fish-tail rudder, the whole system working on the principle of a man sculling with a single oar at the rear of a boat, or a fish's tail.

No. 18.—MR. DONNITHORNE

This exhibit was a combined elevator and radiator for aëroplanes. The apparatus was of the Phillips, or slats of a venetian blind, type, the cooling water being forced through the slats, which are made hollow.

No. 19.—MR. J. DONOVAN, M.Aër. Soc.

This exhibit consists of a circular sustainer to which the chassis is connected by uprights. Propulsion is effected by two 2-bladed propellers in rear, behind which is placed a vertical rudder for steering. Equilibrium is maintained by two small screws, on a single axle, turning in opposite directions, which are fixed above the sustainer; the air, driven downwards, passes through a hole in the latter.

Nos. 20, 21, 22.—MR. FOSTER

The principal exhibit was a very ingenious apparatus for teaching the use of the balancing levers of an aërop'ane. The pupil's seat is fixed on a sort of stand by a ball-and-socket joint, and he keeps his balance by using the levers to regulate an arrangement of weights, which latter must be in certain positions in order to keep the seat on a level keel.

No. 23.—MR. B. FRANCIS

A model aëroplane, the most noticeable point of which was the very great hollow at the front edge of the sustainers.

Nos. 25, 26.—MR. J. GAUNT

A peculiar-shaped aëroplane fitted to a bicycle, the object of which was to reduce the weight of the man and machine by the air lift acting upon the aëroplane. Mr. Gaunt stated that at 25 miles an hour a lift of 42 lbs., or nearly one-quarter of the total weight of machine and rider, is obtained.

No. 28.—MR. C. HATFIELD

There was a neat model of the "Silver Dart" on this stand; it appeared to be the only specimen of this type of machine in the Exhibition.

No. 30.—MR. SYDNEY HOLLANDS

One of his propellers, a workman-like specimen, the peculiar section being cut with great accuracy.

Nos. 32, 33.—MR. W. HOWARD

This exhibitor won the third prize at the Alexandra Palace show in 1907. His exhibit consisted of some nice gliders, etc., very similar to his previous ones.

Nos. 36, 37, 38.—MR. M. KAY

Very neatly turned out models of the Langley type, fitted with motors.

Nos. 48, 49, 50.—ORLEANS MOTOR CO.

Two models, one with flat plane in front, adjustable tail, and 4-bladed propeller in front; another of the box kite or Hargreaves type, with two propellers in front.

Nos. 51, 52, 53.—MR. H. PASSAT

Models of different kinds of wings, some of which appeared to give a very satisfactory lift.

Nos. 56, 57.—MR. H. PIFFARD

Three well-made models after the Chanute pattern with additional fore and aft planes. Fitted with an ingenious device for automatic stability by sliding the main sustainers.

Nos. 61, 62.—MR. C. POWELL

A Bi-plane, the most notable feature being the Turnbull curves in the sustaining surfaces.

No. 64.—MR. A. V. ROE

This gentleman won the second prize at the Alexandra Palace show in 1907. His exhibit consists of a neatly-made Bi-plane some 5 ft. across.

No. 76.—MR. A. E. TAYLOR

A metal cone, to be placed at the front end of a dirigible balloon, the object being to prevent the fore end sagging when it meets an opposing wind.

No. 84.—MR. E. A. WHITBY

The Lester-Best Airflight Device

This is a very ingenious system of lifting, driving, etc., suitable for dirigible balloons. At each of the four corners of the car small paddlewheels working in a case are fixed. Part of the paddle-boxes (about one-third) are open, and when the paddles are set in motion the air is driven out through these openings. To rise, the paddle-boxes are rotated so as to have the opening downwards, the reaction of the air thus driven out causing the whole machine to lift. Similarly, when it is required to descend, the opening of the paddle-boxes is moved to the upper side, and the machine falls. Forward and backward progression are managed in the same way. The whole design is extremely ingenious, as not only can the movements above described be carried out, but by a system of movement of the paddle-box axles steering in any direction can be effected.

No. 86.—MR. G. A. PEACHE, M.Aër.Soc.

A neatly-made tandem type model with tail.

REMARKS

The principal points to notice about the exhibits in this show are:—

1. The bulk of the machines were of a modified Voisin type, only two monoplanes of the bird type being shown. This is much to be regretted as there is no doubt that the bird type is an extremely important one, and that a scientific application of the principles of bird flight may in the end give the most satisfactory results.

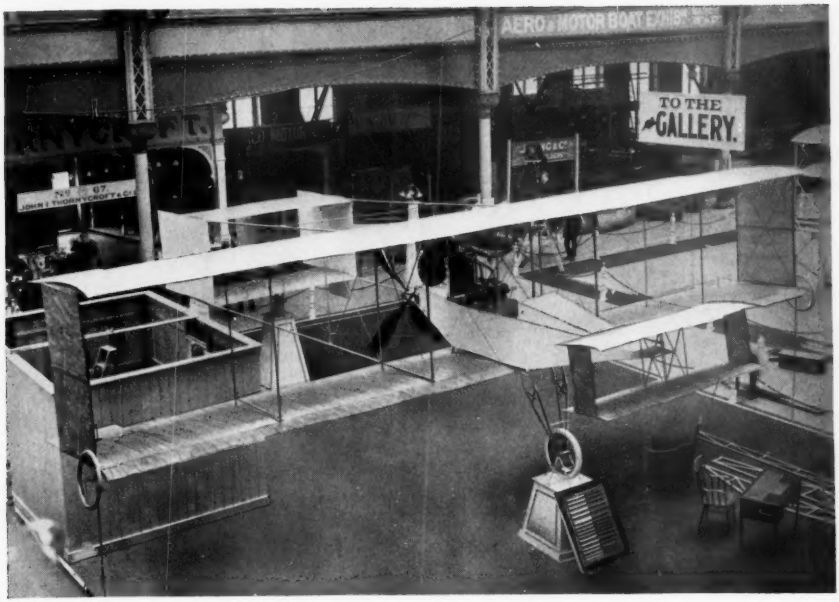
2. The very great size of the full-sized machines exhibited. Most of these would require a housing shed having something like 2,000 sq. ft. of floor space, and when it is considered that at the very most they only carry two persons it is evident that some reduction in size is an absolute necessity.

One machine, the Breguet-Richet, is so constructed that its sustainers can be folded up, thus considerably reducing the floor space required, while the Weiss machine, which is much smaller than any of the others, only occupies about 1,000 sq. ft. But with the exception of these two machines the housing accommodation required is very considerable, and a reduction in the size of flying machines is much wanted.

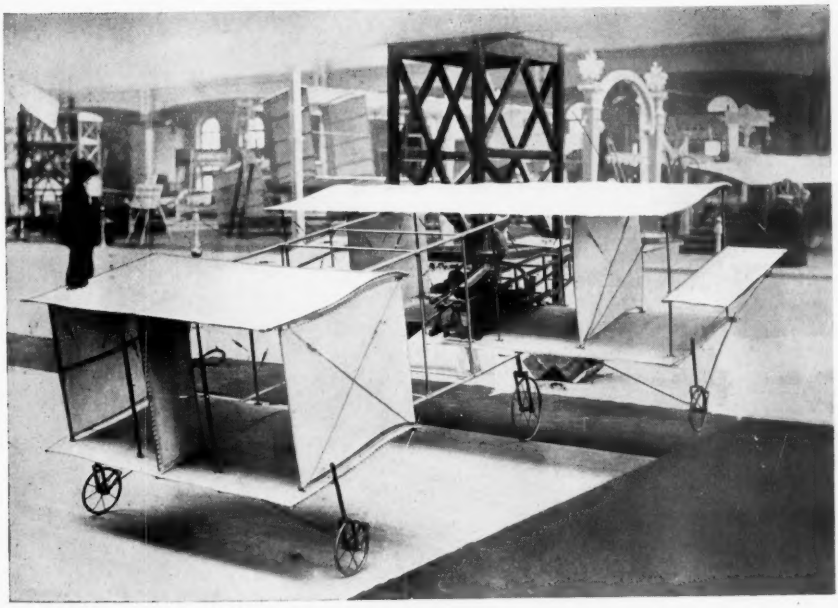
3. The large amount of power required to drive the machines. Most of them only carry about 40 lbs. per B.H.P. at speeds of from 36 to 40 miles an hour, which compares most unfavourably with the fast flying birds, which carry nearly three times as much.

The main reason for this is the large amount of so-called "head resistance," which, in many cases, appears to be about one-sixth of the weight of the whole machine. A reduction in this is very much required, as it is impossible to get good results when the ratio of lift to drift is so large.

4. The carrying capacity of the sustainers was fair, most of them seemed to have a lift



The Howard Wright Bi-Plane



Mr. J. D. Tinline's Model Bi-Plane

to drift ratio of about $\frac{1}{12}$ when inclined at a low angle, while some, like the Weiss, for instance, appeared to have a better ratio still. In most cases the sustainers were fixed to the bodies, that is to say, the angle of inclination relative to the body could not be altered, but in a few cases the sustainers were movable, and this appears to be an improvement.

5. Most of the machines had no bodies, the driver and passenger being seated on the lower sustainer, quite in the open. This, of course, increases the head resistance, and it would seem to be an improvement to adopt the bird type of body, as is done in the Esnault-Pelterie and Weiss machines.

6. The motors do not call for much comment here, as most of them are more or less well known. It is satisfactory to find that "reliability" is now being considered as well as weight reduction, the truth being that reduction in weight of the motor is not so important as improved *design of the whole machine*, because the better the design, the less the H.P. required for propulsion, and, consequently, the less the weight of the motor.

7. *Propellers.*—Most of these seem to have an efficiency of about 70 per cent., though one designer claimed 85 per cent. The latter was certainly beautifully turned out, but some really good propeller tests to find the true efficiencies when running at *their designed speed* are much required.

8. Steering in a vertical plane was nearly always arranged for by means of an elevator, but there were some exceptions. The Esnault-Pelterie's movements were commanded by a tail plane; those of the Breguet-Richet by alteration in the angle of the front sustainers; while in the Weiss machine the variations in the angle of attack are made by alterations in the position of the driver. On the whole, movements of the tail seem to be the most satisfactory, though for small machines the Weiss system is probably sufficient.

9. Steering in the horizontal plane was in nearly all cases arranged for by vertical rudders of the ordinary ship type. In the Weiss machine the tips of the wings can be warped, but it is doubtful whether this last arrangement or the flap system are satisfactory, as interference with the main supporting plane should be reduced to a minimum.

10. *Starting.*—Most of the machines are designed to start by running along the ground, rising taking place when a velocity of about 30 to 36 miles per hour is attained. On the whole, this seems to be the most satisfactory plan, especially for what are, after all, more or less experimental machines.

11. *Alighting.*—This does not call for much comment, as the idea of all the designers was, practically speaking, the same, viz., to check the horizontal speed when approaching the ground, by either warping the wings or altering the inclination of the tail, or elevating planes, and thus alight with moderate vertical and horizontal velocities.

12. As regards longitudinal stability, most of the machines appeared to be stable enough. The Weiss machine is a most remarkable one as regards this point, as it has no tail to counterbalance any dipping motion; nevertheless, its stability seems to be remarkably good, as the numerous models made by the designer testify.

13. Lateral stability is maintained in nearly all the machines by some form of warping the wings by vertical planes between the sustaining planes of the Bi-planes or a combination of these two systems. A good deal more information is required on this subject, as it is doubtful whether any of the machines would retain their lateral stability if they were by any chance required to make an exceptionally sharp curve.

14. *Methods of construction.*—There is no question that British designers can quite well hold their own as regards construction. Many of the machines were beautifully worked out, and while opinions may differ as to the advisability of using so much wood, there is no question that, in attention to details, British makers have very little to learn from our foreign visitors.

REVIEWS

Astronomische Ortsbestimmung im Ballon.—By Professor Dr. Adolf Marcuse. With 10 Tables, 3 Maps, and 3 Illustrations; 67 pp. (Georg Reimer: Berlin; 1909).

This book deals admirably with a subject that has not received on this side of the Channel the attention it deserves. Sooner or later aëronauts will be obliged to make themselves acquainted with simple methods of locating their position; and it should be noted by Englishmen that Professor Marcuse impresses on Germans the importance of astronomical navigation because "they are liable to drift towards the sea." He also points out the advisability of knowing exactly where one has landed when the life of the aërostat is at an end.

The book under review is intended to be a handy manual for aëronauts; and the author commences by stating that there are three methods of navigation:—(1) The geographical,

which has been much improved by the publication of aëronautical maps; (2) the magnetic, which awaits further development; and (3) the astronomical, with which the present volume is principally concerned.

The chief instruments recommended are: A quadrant provided with a spirit-level, an azimuth compass, and a first-class watch. Those who are acquainted with Moedebeck's "Pocket Book" will note that Professor Marcuse substitutes the spirit-level quadrant for the sextant; and it would appear that for aërial observations the former possesses undoubted advantages. Careful directions are given as to the disposal of the various instruments in and around the car; and it is advised that some of them should be fixed to small brackets or stands, as this facilitates manipulation and ensures greater accuracy. The best position for the principal compass, it seems, is when it is suspended from a bar overhead, and it is pointed out that as the under side is transparent the observer can note the direction of the needle by looking upwards.

The author draws attention to the importance of previously testing all instruments *in the car*, and states that the latter should not be too close to the envelope in order that heavenly bodies can be observed when they happen to be not far from the meridian.

At night it is possible to locate the position by observations of bright fixed stars, the moon, and the larger planets. If the moon only is visible, the author claims that a fairly accurate computation can be obtained with the aid of a particular fluid compass. These specially-constructed instruments cost £20, and it is important to note that some of them are compensated in order to counteract the influence of the motor in dirigible balloons.

In addition to the usual methods of obtaining latitude and longitude, there are some valuable hints for quickly locating the position in a case of emergency; and, where extreme accuracy is required, the author indicates in plain language the correct method of procedure.

Altogether, it may be recommended as an excellent and up-to-date guide for aërial voyagers.

"Des Helices Aeriennes."—By S. Drzewiecki. With Tables; 62 pp. (F.-Louis Vivien: Paris; 1909: 2fr. 50).

It is generally acknowledged that the subject of aërial propellers is most important; but unfortunately the data available for designers are very meagre. In these circumstances this little volume will be welcomed on both sides of the Channel for two reasons: In the first place it covers the ground traversed by an investigator whose work is characterised by continuity and by singleness of purpose; and, secondly, it is written by one who has devoted many years to the elaboration of his theories. In fact, the author is entitled to be included among those who have done the "spade work" without which some recent successes might not have occurred.

So far back as 1892 M. Drzewiecki presented to the Association Technique Maritime a work in which he propounded a theory for calculating the correct dimensions and shape of propellers; and this met with such a favourable reception at the hands of well-known marine engineers and scientists, that he was encouraged to verify his deductions by applying them to existing and prospective propellers. The results proved eminently satisfactory; and it was discovered that those were the best screws which came nearest to the conditions imposed by his calculations. Furthermore, it was found that certain peculiarities, which could not be explained by ordinary methods, presented no difficulties under the application of his theory.

The author goes most carefully into all the conditions governing a really efficient propeller, and appears anxious that his readers should obtain a clear mental vision of the phenomena, which, as he says, "escape the eye." He is not an advocate for devoting too much attention to the production of the lightest possible propeller, because it is shown that any diminution in the weight of the screw has no appreciable effect in lightening the whole apparatus, and may, on the other hand, detract from the driving power.

Not the least valuable portion of the work is that in which the author gives details for the construction of a testing-apparatus; and as the cost of the installation does not appear to be excessive, it should commend itself to the attention of those who are now engaged in experiments with this branch of aëronautics.

The chief merit of the treatise lies in the fact that the presentation of the whole subject is simple; and this is true for most of the mathematical work, with which it abounds, as well as the descriptive matter. For the student who knows French a better guide could scarcely be found; but it is to be hoped that in a future edition the author will find it possible to arrange his valuable data under separate and well-defined headings; for in its present condition it hardly does justice to the painstaking research of which it is evidently the outcome.

"L'Aeroplane Pour Tous."—By Louis Lelasseux and René Marque. With Illustrations; 120 pp. (Société d' Editions aéronautiques: Paris; 1909: 2fr.).

This book brings into a convenient compass much useful information in connection with aëroplanes and the theoretical principles of their flight. The authors classify them as

(1) monoplanes; (2) biplanes; and (3) polyplanes. They discuss the military application of heavier-than-air machines, and, while admitting that the latter are incapable of carrying guns for purposes of attack, it is pointed out that their speed will enable them to drop unexpected bombs on the staff in the field, and thus make away with officers "whose existence is particularly useful to the army." For the rank and file the flying machine promises to be only a demoralising agent "par excellence."

H. J. C.

"Sur un Formule de M. A. Berget, pour le Coefficient D'Utilization des Dirigeables."—The author of the above paper, Captain Castagneris Guido, has a double object. First he draws attention to the large number of miscellaneous papers on aëronautical matters which from time to time have been submitted to the Academie des Sciences, and to the utter worthlessness of many of them. He protests against this abuse of the privilege of submitting papers to the Academy.

Then, to press home his point, he takes the paper alluded to in the above title, and shows it to be a case in point.

M. Berget suggested a formula* involving the horse power, speed, and gross sectional area of a dirigible, and obtained from it a "Figure of Merit" for each of the past and present types.

Captain Guido points out the absurdity of attempting such a task at all, and then criticises the particular formula in detail.

He observes that the volume, and ratio of length to diameter ought certainly to be taken into consideration, and modifies the formula of M. Berget accordingly, while at the same time expressly denying any value to the result.

He then gives tables showing the figures of merit of various types as calculated by the rival formulæ.

The original formula puts "Lebaudy" top, "La France" half-way down the list, and "Zeppelin III." (now modified to Z.I.), at the bottom. The revised formula exactly reverses this order.

If there is anything in Captain Guido's protest against the submission of worthless papers, then he himself appears to have sinned by adding to their list. But all those who aim at progress rather than at the maintenance of a high standard of intellectual discussion in matters aëronautic will regret Captain Guido's protest for a very different reason. Our difficulty is to get the thinkers and experimenters to make public their ideas, and far from attempting to discourage them through fear of criticism we should each of us by our own example and encouragement endeavour to swell the thin trickle of information which reaches us through pamphlets and papers. Some of it may be of small value, but no matter.

So we can only express a hope that Captain Guido's paper will fail in its attempt to check this flow, and that as time goes on he himself, or others, may be able to improve on his present formula until it does become a thing of value.

* In a paper presented to the *Académie des Sciences* on January 4, 1909.

Foreign Aëronautical Publications

(In this list a selection of the more notable articles only is given.)

L'AEROPHILE

January 1st, 1909.—The Velocity of Aëroplanes.—Sailing Flight and Wing Forms.—The Eiffel Experiments on Air Resistance.—"Antoinette V."

January 15th, 1909.—The Transverse Stability of Aëroplanes. The R.E.P. Aëroplane and Its Motor.—Messrs. Wright's Flights.—The First Aëronautical Salon.

February 1st, 1909.—The Necessity for Aëro Garages (José Weiss).—The Wright and French Aëroplanes.

February 15th, 1909.—The Military Aëroplane.—The Gyroscope and Aviation.—A Contribution to the Study of Aëroplanes.—The Maurice Farman Aëroplane.

March 1st, 1909.—The Wright and French Aëroplanes.—The Bleriot Aëroplanes. The Dirigible Balloon Zodiac.

March 15th, 1909.—From a Model Aëroplane to One of Greater Size.—Principles of Sailing Flight.—Contribution to the Study of Aëroplanes.—The Bleriot Aëroplanes.

AERONAUTICS (America)

January, 1909.—Flying Machines at Morris Park.—Aërial Experiment Association Work.—Principles Involved in the Formation of Wing Surfaces and the Phenomenon of Soaring.—Some Early Gliding Experiments (Montgomery).

February, 1909.—Hammondsport Work of the Aërial Experiment Association. The Helicoptère.—Helicoptères for Aërial Research.

L'AERO-MECANIQUE

January, 1909.—Beating Wings.—Motors at the Aëronautical Salon.—Experimental Sailing Flight.

LA REVUE DE L'AVIATION

January, 1909.—Curved or rectilineal flight.—Our Physiological Faculty of Flight.—The Aëronautical Salon.—How to Construct and Experiment with Small Flying Models.

February, 1909.—On the Turning of Aëroplanes.—A Velocity Formula for Dirigibles.

March, 1909.—The Military Aëroplane.—The Victor Tatin Monoplane.—The Ownership of the Air.

SOCIETA AERONAUTICA ITALIANA

No. 1.—January, 1909.—The Principles of the Conservation of Energy Applied to the Vertical Movements of Bodies Immersed in Fluids.—Miscellaneous Flying Machines.—Dirigibles.—Aëronautical Motors.—Scientific Chronicle.

No. 2.—February, 1909.—The Principles of the Conservation of Energy (cont.).—An Italian Balloon for Studying the Upper Atmosphere.—Miscellaneous Flying Machines.—Aëronautical Motors.—Scientific Chronicle.

ILLUSTRIERTE AERONAUTISCHE MITTEILUNGEN

January 13th, 1909.—The Michelin Prize.—The Wright Bros.' Flying Machine.—The Stability of Flying Machines.—The First Airship Exhibition.

January 27th, 1909.—The Gordon-Bennett Race, October 12th and 13th, 1908.—Conference of the International Airship Association.—The Wright Bros.' Early Experiments.—The Voisin Flying Machine.

February 10th, 1909.—Motors at the Paris Exhibition.—Miscellaneous Flying Machines.

February 24th, 1909.—The American Government Experiments.—Miscellaneous Flying Machines.

March 10th, 1909.—The American Government Experiments.—Notes on the Steering of the Esnault-Pelterie Machine.—The "Silver Dart."—The Coming International Exhibition at Frankfort.—Miscellaneous Flying Machines.

WIENER LUFTSCHIFFER ZEITUNG

January 1st, 1909.—The Gordon-Bennett Prize.—In a Balloon Over the North Sea.—The Gross and Zeppelin Ballcons.

January 15th, 1909.—The Paris Exhibition.

February 1st, 1909.—The London Congress.—Miscellaneous Notes.

February 15th, 1909.—At Monaco.—A Sledge with an Air-Screw (Wels).—The Zippel Experiments in Berlin.

March 1st, 1909.—The Bros. Wright.—Letter from Pau.

March 15th, 1909.—At Monaco.—Stability of Aëroplanes.

Applications for Patents

(*Made in January, February, and March,* 1909)

The following list of Applications for Patents connected with Aëronautics has been specially compiled for the AËRONAUTICAL JOURNAL by Messrs. BROMHEAD & Co., Patent Agents, 33, Cannon Street, London, E.C.

JANUARY

47. January 1st. P. A. WATSON. Improvements in flying machines.

101. January 2nd. B. A. E. HART. Improvement in the method of propelling aeroplanes.

123. January 2nd. A. CLEMENT. Improvement in dirigible aerostats and the like.

205. January 4th. G. A. METCALF. Improvements in aeronautic apparatus.

217. January 4th. C. SCOTT-SNELL. Captive aeroplanes.

307. January 6th. J. T. PICKERSGILL. Improvements in aeroplanes or flying machines.

463. January 7th. L. BLERIOT. Improvements in or relating to aerial machines.

602. January 9th. SIR H. S. MAXIM. Improvements in or relating to apparatus for aerial navigation.

704. January 11th. L. J. KEMPSTER. Improvements in dirigible balloons.

750. January 12th. A. V. ROE. Improvements in flying machines.

753. January 12th. E. E. SMITH. Improvements in dirigible airships.

755. January 12th. W. H. APPLEBY. Improvements in and relating to aeroplanes and flying machines.

771. January 12th. F. C. WOODWORTH. Flying machine.

863. January 13th. N. H. C. WILLIAMS and ANR. Improved flying machine.

962. January 14th. J. E. NEAL. Improvements in or relating to aeroplanes.

1051. January 15th. H. C. BARBER. Improvements in aeroplanes.

1303. January 19th. H. F. FIETH. Improvements in aeronautical machines.

1351. January 19th. R. W. TAYLOR. Improvements in aeroplanes.

1402. January 20th. H. F. PHILLIPS. Improvements in or relating to flying machines.

1497. January 21st. A. W. Dennis and Anr. Flying Machine.

1514. January 21st. J. Kuhajda. Improvements in flying machines.

1528. January 21st. F. Kopsch. Improvements in flying machines.

1632. January 22nd. H. T. Wright and Anr. Improved means for propelling aeroplanes, dirigible balloons, and the like, being also applicable for propelling vessels through water.

1639. January 22nd. F. R. Sims. Improvements in or connected with aerial machines.

1640. January 22nd. F. R. Sims. Improvements in aerial machines.

1656. January 23rd. A. Worswick. Improvements in balancing and steering aeroplanes and the like.

1709. January 23rd. W. C. Johnson. Improvements in flying machines.

1803. January 25th. A. H. Holle. Improvements in aeroplanes.

1909. January 26th. A. Smikalla. Automatic flying machine.

1999. January 27th. H. C. Barber. Improvements in aeroplanes.

2111. January 28th. H. C. Lobnitz. Improvements in and relating to aerial machines.

2131. January 28th. A. W. Dennis and Anr. Propellers for flying machines.

2165. January 29th. R. Schwarz and Anr. Improvements in machines for navigating the air.

2166. January 29th. J. Gordon-Bell. Improvements in flying machines.

2304. January 30th. W. J. Griffiths. Apparatus for automatically controlling the vertical movements of aeroplanes.

FEBRUARY

2397. February 1st. F. R. Sims. Improvements in or connected with aerial machines

2446. February 2nd. A. Tomlins and Anr. Improved aerial machine or carriage or motor driven by electricity or other motive power.

2467. February 2nd. T. J. Edwards. Flying machine.

2540. February 2nd. R. P. Elworthy. Improvements in aerial machines.

2572. February 3rd. T. F. Robinson. Improvements in kites, aeroplanes, and like appliances.

2575. February 3rd. L. B. Goldman. Aero-Car.

2606. February 3rd. R. T. Deane. Improvements in aeroplanes.

2741. February 4th. A. Tribelhorn. Improvements in airships.

2744. February 4th. A. Edwards. Improvements in or relating to propeller driving for various purposes.

2913. February 6th. O. Wright and Anr. Improvements in or connected with flying machines.

2926. February 6th. C. Mahnkopf. Improved airship.

2932. February 6th. A. W. Isenthal. Improvements in or connected with the practice or acquirement of the art of aviation.

3144. February 9th. S. F. Cody. Improvements in and relating to propulsion by screw propellers, rotating fans, and the like.

3202. February 9th. J. Means. Improvements in controlling apparatus for flying machines.

3412. February 9th. R. Tucker. Flying apparatus.

3455. February 12th. C. E. Richardson. Improvements in kites.

3503. February 12th. G. G. M. Hardingham. Improved aeronautical machine.

3535. February 12th. W. Briebley. Improvements in airships.

3616. February 13th. L. S. Kear. Navigable flying machine.

3645. February 15th. J. L. Garsed. Improvements in rotary propellers applicable to aerial machines, steamships and boats.

3697. February 15th. L. Rottenburg. Improvements in aeroplanes.

3728. February 15th. V. H. Donnithorne. Improvements in radiators and control planes for air vessels.

3837. February 16th. L. F. Durell. Improved aeroplane and aerial railway.

3908. February 17th. D. F. Rourke. Improvements in and relating to airships.

3932. February 17th. P. F. Degn. Improvements in flying machines.

3962. February 18th. J. G. H. Batchelor. Improvements in or relating to flying machines.

3965. February 18th. S. H. Hollands. Improvements in aeroplanes and the like, and in self-contained auxiliary starting apparatus for same.

4006. February 18th. H. Rosenberg. Improved device for throwing explosive shells from airships.

4097. February 19th. W. C. Vincent. Improvements in propellers for aerial purposes.

4217. February 20th. T. Zorn. Airship.

4348. February 22nd. J. T. Rice. Airships.

4473. February 23rd. Sir H. S. Maxim. Improvements in or relating to apparatus for aerial navigation.

4525. February 24th. E. Coulon. Improved roadster aeroplane.

4607. February 24th. F. D. Henderson. Eccentric paddle designed for displacement of atmosphere.

4624. February 25th. H. A. Sanders. Improved aeroplane or flying machines.

4642. February 25th. P. A. Vaile. Improvements in aeroplanes.

4803. February 26th. C. V. Moorsel. Improvements in flying machines.

4812. February 27th. C. H. A. Verity. New or improved flying machine or aeroplane.

MARCH.

4945. March 1st. R. M. Alexander. Improvements in or connected with aerial machines.

4954. March 1st. C. M. G. Jensen. Improvements in or relating to dirigible flying machines.

5133. March 3rd. J. L. Garsed. Improvements in or connected with propellers or aerial machines.

5221. March 4th. J. B. Goldman. Improvements in aerial machines.

5391. March 5th. J. R. Porter. Improvements in airships.

5550. March 8th. G. St. J. Wood. Improvements in flying machines.

5628. March 9th. J. L. Garsed. Improvements in propellers for aerial machines.

5649. March 9th. J. E. Duggan. Improvements in aeroplanes.

5662. March 9th. R. Brocklehurst. Improvements in or connected with mechanical flying machines.

5699. March 9th. H. A. Franklin and Ors. Improvements in and relating to aeroplanes.

5716. March 9th. R. C. Balston. Improvements in or relating to flying machines.

5720. March 10th. H. Piggott. Improvements in flying machines, aeroplanes, biplanes, balloons, aerofoils, and the like.

5910. March 11th. J. F. F. W. Ure. Gyrostatic action, free and unchecked, applied to aeroplanes and other unstable bodies.

5915. March 11th. W. G. Robertson and Anr. Improvements in propellers for aerial machines.

6017. March 12th. F. B. Goodchild and Anr. Improvements in the method of starting and controlling airships.

6021. March 12th. J. Weiss and Anr. Improvements in or relating to aeroplanes.

6038. March 13th. Wolseley Tool & Motor Car Co., Ltd., and Anr. Improvements in the driving mechanism of vessels for aerial navigation.

6072. March 13th. C. Weigmann. Improved flying machine.

6092. March 13th. N. W. Blood. Improvements in or relating to flying machines.

6119. March 15th. J. L. Garsed. Improvements in or connected with propellers of aerial machines.

6125. March 15th. C. P. Foster. Aeroplane or flying machine.

6154. March 15th. S. J. Przyjemski. Contrivance to reduce the run of flying machines before rising.

6310. March 16th. J. T. Bowden and Anr. Improvements in aeroplanes.

6366. March 17th. C. Gerullis. Improvements in airships.

6378. March 17th. G. P. Ottings and Anr. Improvements in aerostats or heavier-than-air machine.

6414. March 17th. H. B. Molesworth. Improvements in or connected with aerial machines and propellers.

6500. March 18th. S. J. Przyjemski. Aeroplane improvements.

6568. March 18th. J. B. Passat. Improvements in flying machines.

6598. March 19th. C. E. Richardson. Improvements in aerial machines.

6647. March 19th. G. H. Pointer. Improvements in aeronautical machines.

6648. March 19th. G. H. Pointer. Improved means applicable for use in launching aeronautical machines.

6745. March 20th. L. Bleriot. Improvements in or relating to the cooling of the circulation water in motors for dirigible balloons, aeroplanes and similar apparatus.

A MAP FOR AVIATORS

We have received from the publisher, E. Blondel la Rongery, a map of Paris for aviators, entitled "Les Sorties de Paris à vol d'oiseau."

In this map the Place de la Concorde is taken as the centre from which radii are drawn, showing the precise direction and distance in kilometres by air of the principal cities of France and of Europe.

The hangars and the hydrogen and coal-gas works and the dangerous places for flying machines in the neighbourhood of Paris are also plainly marked.

The map speaks well for the enterprise of the Aëro Club of France, by whose authority it is issued, as well as for the publisher.

THE AËRONAUTICAL JOURNAL

BACK NUMBERS

Back Numbers, excepting No. 2 (April, 1897) and No. 9 (January, 1899), which are out of print, may be obtained from the Publishers: Messrs. KING, SELL & OLDING, LTD., 27, Chancery Lane, W.C.

The following are some articles of special interest which have appeared during the last few years:

Lord Rayleigh on Flight;

The Balloon Work of the late Mr. Coxwell; and

A Theory of Flight. By D. M. BOYER SMITH. April, 1900. 1s.

On Forms of Surfaces Impelled Through the Air and their Effects in Sustaining Weights. By F. H. WENHAM. July, 1900. 1s.

Cloud Photography from a Balloon. By the late Rev. J. M. BACON; and

The Lifting Power of Air Propellers. By WILLIAM GEORGE WALKER. October, 1900. 1s.

The Paris International Aeronautical Congress. January, 1901. 1s.

The Experiments with the Zeppelin Airship, April, 1901. 1s.

Aeronautics in France. By WILFRED DE FONVIELLE. July, 1901. 1s.

The Chief Scientific Uses of Kites. By A. LAWRENCE ROTCH. October, 1901. 1s.

Aerial Navigation by Means of Bodies heavier than Air. By Sir HIRAM MAXIM; and

Atmospheric Currents. By WILLIAM MARRIOTT. January, 1902. 1s.

The Berlin Congress of the International Aeronautical Commission. July, 1902. 1s.

The "Peace" Balloon of the late Senhor Augusto Severo. By Dr. CARLOS SAMPAIO. October, 1902. 1s.

Contributions of Balloon Investigations to Meteorology. By Dr. W. N. SHAW, F.R.S.; and

Recent Aeronautical Progress. By Major B. BADEN-POWELL. January, 1903. 1s.

The Development of the Aeroplane. By Major BADEN-POWELL; and

Scientific Balloon Ascents. By CHARLES HARDING. October, 1904. 1s.

Kites, Kite-Flying and Aeroplanes. By W. H. DINES;

Man-Lifting Kites; and

Captive Balloon Photography. January, 1905. 1s.

Automatic Stability. By E. C. HAWKINS, J.P. April, 1905. 1s.

Some Remarks on Aerial Flight. By F. H. WENHAM;

Demonstration of a Bird-like Flying Machine. By Dr. F. W. H. HUTCHINSON; and

Balloon Varnishes and their Defects. By W. F. REID. October, 1905. 1s.

The Acoustical Experiments Carried Out in Balloons by the late Rev. J. M. Bacon. By GERTRUDE BACON. January, 1906. 1s.

The late Prof. S. P. Langley. April, 1906. 1s.

The Use of Kites in Meteorological Research. By Dr. W. N. SHAW;

The Stability of the Conic Shape in Kites and Flying Machines. By R. M. BALSTON. January, 1907. 2s.

The Distribution of Weight in Aeroplanes. By M. F. FITZGERALD;

Special Report and Photographs of the Kite Display on Chobham Common. July, 1907. 2s.

Three Airships of Three Nations, with plates of the "La Patrie," The "Parseval," and British Military Airships. October, 1907. 1s.

The Starting Methods of Aeroplanes. By JOSÉ WEISS; and

Mechanical Aerial Navigation. By RANKIN KENNEDY. January, 1908. 1s.

Experiments with Dipping Planes. By Major B. BADEN-POWELL; and

The Farman Flying Machine. By Col. J. D. FULLERTON; and

The Rotation of Planes in Air, with especial reference to Aerial Screws and Propellers. By W. B. PARSONS, M.R.C.S. April, 1908. 2s.

Notes on the Phillips Flying Machine. By Colonel J. D. FULLERTON, R.E.; and

The Efficiency of Aeroplanes and Propellers. By W. R. TURNBULL, M.E.; and

Stability of Aeroplane Support for Flying Machines. By F. H. WENHAM; and

The Conditions of Equality of Statical Stability between the "Patrie" and the "Zeppelin." By Capt. GUIDO CASTAGNERIS. July, 1908. 3s.

Helicopters *v.* Aeroplane. By H. CHATLEY, B.Sc.; and

The Construction of Detailed Parts of Aeroplane Flying Machines. By F. H. WENHAM; and

The Wright Bros.' Flying Machine. By Colonel J. D. FULLERTON, R.E. October, 1908. 1s.

The Wright and Voisin Types of Flying Machine. A Comparison. By F. W. LANCHESTER; and

Experiences with the Wright Machine. By Major B. BADEN-POWELL; and

Experiences with the "Power Kite." By S. F. CODY. JANUARY, 1909. 2s.

The Aeronautical Society of Great Britain

ANNUAL REPORTS

Copies of the Annual Reports may be obtained from the Librarian, Aeronautical Society, 53, Victoria St., S.W., at the following prices:—

1866	1st Annual Report	Out of Print
1867	2nd , ,, ...	,,
1868	3rd ,, ,, ...	7/6
1869	4th ,, ,, ...	7/6
1870	5th ,, ,, ...	7/6
1871	6th ,, ,, ...	7/6
1872	7th ,, ,, ...	7/6
1873	8th ,, ,, ...	7/6
1874	9th ,, ,, ...	Out of Print
1875	10th Annual Report	5/-
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